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PHASE I REMEDIAL INVESTIGATION REPORT

(TABLES AND FIGURES)

SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA
DELTA NO. 10-88-706

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May 18, 1990

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1.0 INTRODUCTION

1.1 Authorization and Purpose

In December 1988, Delta Environmental Consultants, Inc. (Delta), was authorized to complete a remedial investigation (RI) at the Schloff Chemical and Supply Company, Inc. (Schloff), site in St. Louis Park, Minnesota. The RI was undertaken in response to a request by the Minnesota Pollution Control Agency (MPCA) to investigate the Schloff site as a potential source of 1,1,2,2-Tetrachloroethylene (PCE) in surficial ground water monitoring wells at a nearby property. The property proximate to the Schloff site is an active investigation, conducted by Control Data Corporation (CDC) Printed Circuits Operation (PCO), south of Minnehaha Creek which previously identified chlorinated volatile organic contaminants (VOC) in soil and ground water below the site.

This document is consistent with the RI requirements set forth in the Request for Responsive Action (RFRA) issued to the Schloff Chemical Company by the MPCA, as well as consistent with the amended National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Part 300 or as amended under the Superfund Amendments Reauthorization Act (SARA) and with the United States Environmental Protection Agency (EPA) Guidance for Conducting Remedial Investigations and Feasibility Studies under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (October 1988 Interim Final).

The purpose of this report is to present the information collected to date, which has been used to:

- Identify known sources of PCE contamination.
- Evaluate the nature and extent of soil, surface water, and ground water contamination related to the site.
- Identify existing and potential migration characteristics and pathways for contaminants caused by on-site activities, including the direction, rate, and dispersion of contaminant migration.
- Provide information and data needed to evaluate the interim response action, and the potential need for future remedial action.

1.2 Scope of Work Performed

A brief description of the services provided by Delta during the initial RI phase of this project include the following:

A site reconnaissance visit to construct a detailed site map and to identify potential drilling locations. Reviewing the existing data from the adjacent CDC - PCO site aided in determining the site geology and hydrology. With this information Delta supervised and directed the drilling of seven soil borings and the installation of seven ground water monitoring wells (MW-1S through MW-7S) at the site. The monitoring wells were surveyed to a common USGS datum, and tied into the wells at the CDC - PCO site. Soil and water samples were collected from site monitoring wells and Minnehaha Creek which have provided a data base to establish site conditions. Ground water levels have been routinely monitored to evaluate the ground water flow directions and hydraulic gradients needed to delineate ground water discharge areas, and aquifer tests have been conducted to estimate contaminant transport mechanisms.

Subsequent site work consisted of designing and supervising the construction of a purge well and ground water treatment system as part of an interim response action. The interim response action was initiated to prevent ground water contamination from migrating off-site. Additionally, Delta responded to a February 1989, spill that occurred during offloading of a PCE tank. A sample of the spill was collected from PCE that was ponded on the ground. Continuing investigations concerning the Schloff site consist of interviews with current and former Schloff employees to discuss previous site operations.

2.0 BACKGROUND INFORMATION

2.1 Site Description

The Schloff site is located in a commercial/industrial area of St. Louis Park, Hennepin County, Minnesota. The address is 3938 Meadowbrook Road. The property's legal description is the SW 1/4 of the NW 1/4 of Section 20, T117N, R21W. Figure 1 is a topographical site location map and Figure 2 is a site map. Approximately 50 feet north of the site are Chicago Milwaukee St. Paul Railroad tracks, including a spur to the Schloff building. Increasing distances further north of the site are Northwestern Railroad tracks, a residential area, and a city park. Areas in the remaining directions are used for commercial and industrial purposes. To the south is Merit Gage, Inc. (a manufacturing firm of precisions instruments), and the Musicland Group office and warehouse. East of the site lies Meadowbrook Road and a commercial/industrial business park, including Mid-City Precision (metal plating), Machine Tool Company, Anderberg Lund Co., Maaco Auto Shop, CVN Roofing, Ace Supply, and Westling Manufacturing. To the southeast is the CDC - PCO building. Minnehaha Creek flows near the site to the west and south, between the Schloff and CDC - PCO sites.

In general, most areas on-site are paved. Other areas are covered with grass, including the off-site areas surrounding Minnehaha Creek where the stream banks are covered with thick brush, trees, and tall grass. The areas north surrounding the railroad tracks and right-of-way are also overgrown with brush and grass.

Topographically, the site is relatively flat. Surface drainage from the site is to the west and south. The roughly 29,700 square foot Schloff building occupies approximately 30 percent of the Schloff property. The Schloff building is located in the northern portion of the property, where both railroad and truck deliveries of PCE occur on the northwestern and southwestern side of the building, respectively.

Two 10,000-gallon above ground storage tanks are located on the west side of the Schloff building. Each of the tanks are 10 feet in diameter and 17 feet high. They are surrounded by a concrete dike approximately four feet high. The dike is underlain by a concrete base. The dike system appears capable of preventing a release of PCE to the subsurface environment, and no release has been reported from the diked area. A drain is present on the west side of the dike wall near the base of the dike. This drain was likely constructed to allow precipitation to discharge from the diked area. The tanks were installed and the dike was constructed in 1977. A report describing borings performed prior to construction of the tanks is included in Appendix A.

2.2 Site History

The following discussion is derived from information previously provided by Schloff to the MPCA and from information more recently obtained regarding operations at the site. Information contained in reports and data submitted by CDC from the PCO site have also been employed.

The Schloff site property is owned by Mrs. Ruth Schloff. Prior to 1976, the facility was operated as an appliance and kitchen equipment distributorship by Mr. Sam Rozman. Mr. Rozman had the building constructed in about 1969. Appendix A contains a report describing soil borings completed prior to construction of the building by Mr. Rozman. Schloff operations at the site began in 1976. In January 1989, Schloff was sold to E. Weinberg Supply Company, Inc. (Weinberg), which continued the Schloff operations at the property. There have been two reported spills of PCE at the Schloff site; one in October 1988, while the site was operated by Schloff, and one spill in February 1989, after the purchase of Schloff by Weinberg.

The MPCA issued a Request for Information (RFI) to Schloff on October 26, 1988. In a response to the RFI, Schloff stated that the activities at the site consisted of warehousing and distribution of chemicals and supplies for the retail dry cleaning and laundry industries. Activities included the following: bulk storage, repackaging in various container sizes, and distribution of PCE in bulk and repackaged forms.

The Schloff business was in operation at the site from 1976 through January 1989, after which it has been operated by the new business manager Mr. Bert Weinberg. PCE was handled at the site as part of business operations from 1977 to the present. The facility received PCE shipments by truck transport approximately every two months, typically in 3,500-gallon shipments, and by rail car transport approximately four times per year in 13,000 to 16,000 gallons deliveries.

2.3 Site Operations

Portions of the following section have been assembled from interviews with Schloff employees, and aspects of this investigation are ongoing and subject to modification. As stated previously, operations at the Schloff facility consisted of supplying products to the dry cleaning and laundry industries. A component of the business consisted of the storage, repackaging, and distribution of PCE. In addition to supplying the dry cleaning industry, laundry industry related products are, and were, stored at the facility. These included prepackaged detergents, emulsifiers, bleach, acids, and alkalis.

The following information pertains to former PCE operations at the site. PCE was supplied to the two above ground 10,000-gallon tanks via two pipelines. One pipeline (FP-2) originates at the southwest corner of the building and was used only by transport truck suppliers. The other pipeline (FP-1) starts at the northwest corner of the building and was used only for supplies of PCE brought to the site by rail car transport. For purposes of this report, the fill pipes are labelled FP-1 and FP-2, where FP-1 is the rail car fill pipe and FP-2 is the truck fill pipe (Figure 3). Both fill points consist of quick coupling for connection of hose, and a lockable gate valve.

PCE was delivered to FP-1 by 13,000- to 16,000-gallon rail car loads. FP-1 was designed and used solely to fill the 10,000-gallon storage tanks. No dispensing of PCE for distribution occurred at FP-1. As shown on Figures 3 and 4, a transport car parked on the railroad spur would connect to FP-1. The rail cars off-loaded the PCE via gravity drain to FP-1 which was then gravity drained to the interior pump. Thus, the PCE flowed through the pipeline, to the interior pump where valves controlled the flow of PCE into one of the 10,000-gallon above ground tanks. PCE rail car suppliers included Occidental Chemical Company, Thorson Chemical, and Vulcan Chemical Company through its Chicago agent called R.R. Street Company. Further investigation of this operation, including the dates of rail car freight delivery and these suppliers, is ongoing.

PCE was supplied to and dispensed from FP-2. Transport trucks utilizing onboard pumps delivered PCE to FP-2. The transport truck shipments of PCE were typically 3,500 gallons, delivered approximately every two months to the site. The PCE was drawn through the onboard transport truck pump under pressure to FP-2, then transported by gravity into the interior pump, and finally into the PCE tanks as shown on Figure 4. There were several suppliers of PCE via truck transport including Occidental Chemical Company. Additional truck transport suppliers are being investigated as part of Schloff's ongoing investigation. Subsequently, there is also an ongoing investigation regarding the independent contractors who operated the trucks used to deliver and distribute PCE relating to FP-2.

PCE pumped to either FP-1 or FP-2 was routed into one of the PCE tanks. As the tanks filled, a vent system allowed the release of PCE vapors to the atmosphere. The piping to the vents also acts as an overflow prevention system. During filling, if one tank became full, PCE could naturally flow via gravity drainage to the other tank. Gauges on the wall inside the Schloff building indicate the volume of PCE in each tank. Currently, approximately 3,000 gallons of PCE are contained in the tanks.

PCE was periodically dispensed from FP-2 to independent contract delivery trucks that distributed PCE to Schloff customers (Figures 3 and 4). Typically, the truck owner/operator would be stationed at the truck to observe the filling while a Schloff employee was stationed at the interior pump. The trucker stationed outside would indicate the amount to be pumped (at FP-2) and would knock on the pipe to indicate to the pump operator that the pump should be turned off. It is believed that small spills, in volumes representative of that from a drained hose, would impact the area around FP-2, and possibly drain to the northwest along the asphalt/gravel contact in that area. The asphalt/gravel seam creates a low lying area where surface drainage occurs. A 55-gallon barrel, filled with sand, was kept near FP-2 to apply on any inadvertent surface spills, such as spills occasioned by the trucker's overestimate of the amount to be transferred to the truck. The sand was promptly applied to the spill area to passively soak up the pooled PCE. PCE which did not volatilize or pool migrated into the subsurface. The sand applied to a spill area was deposited into the diked area near the tanks.

A dispensing nozzle (Figure 4) in the interior pump room was also used to transfer PCE from the above ground tanks into small containers of 5, 20, or 55 gallons. The interior pump room is a 20- x 20-foot ventilated room which shows no visible impacts of PCE contamination (stains, rusted beams, floor cracks, drains). A 110-gallon upright tank, located in the interior pump room, was used to further dispense PCE into 5-gallon containers. The tank is equipped with a spigot and sits on a stand so that the five gallon container can be placed under the spigot. The 110-gallon tank is filled using the dispensing nozzle. This was the most common form of repackaging of the PCE. PCE was also repackaged to 55-gallon containers, or more commonly (due to weight) 20-gallon containers, directly from the dispensing nozzle. These processes were performed on an as-needed basis, in response to specific customer requests. Filled containers of PCE were promptly moved within the building to the loading bay area for distribution to Schloff customers (Figure 3). A barrel or fork lift was used to transport the filled containers to the loading docks. The containers were loaded on trucks and delivered to Schloff's customers. The trucks were owned either by independent common carriers or by the Schloff business. No spills of PCE have been reported within the building interior (pump room and loading bay area).

The loading bay area is where containerized PCE was temporarily stored and loaded onto trucks (Figure 3). One loading bay is located inside the building, and was used primarily during the winter. This interior loading bay was utilized exclusively by Schloff trucks, since common carrier trucks were too large for this area. The floor of this bay contains a drain that is open to the subsurface. However, no known spills of PCE have occurred in this area.

2.4 Previous Reports

Considerable correspondence, both written and verbal, has been provided to MPCA by Schloff's legal counsel and environmental consultants. This correspondence includes investigative work plans, preliminary subsurface soil boring and ground water monitoring data, and interim response action plan design and performance. In addition, information and data generated by Conestoga-Rovers and Associates, Limited (CRA) for the CDC - PCO site, have been reviewed, including:

FINAL REPORT
GROUNDWATER INVESTIGATION
Printed Circuits Building
Control Data Corporation
St. Louis Park, Minnesota
May 1987

DETAILED ANALYSIS REPORT
Printed Circuits Building
Control Data Corporation
St. Louis Park, Minnesota
August 1989

PUMPING TEST REPORT
EXTRACTION WELL PW2
Printed Circuits Building
Control Data Corporation
St. Louis Park, Minnesota
January 1989

The reader is referred to these reports for descriptions of the soil and ground water contamination at the CDC - PCO facility.

3.0 PROJECT RESULTS

3.1 Soil Borings

Seven soil borings were advanced at the site under Delta supervision. The locations are illustrated on Figure 5 and are denoted by MW-1S, MW-2S, MW-3S, MW-4S, MW-5S, MW-6S, and MW-7S. The MW designation infers the soil boring number which was completed as a ground water monitoring well, the number is the order in which the boring was completed, and the "S" is to differentiate the wells at the Schloff site from those at the nearby CDC - PCO site. Lithologic boring logs prepared by the drilling subcontractor are included in Appendix B.

The borings were advanced to depths ranging from 22 to 30 feet below grade using hollow stem auger flights. Split spoon soil samples were collected continuously to total depth in MW-1S, MW-2S, MW-3S, and MW-4S continuously to below the water table, and at five-foot intervals thereafter in MW-5S, MW-6S, and MW-7S.

The shallow subsurface geology encountered consists of poor to moderately sorted fine to coarse sand with gravel. In some borings the upper 14 feet contained a higher silt content. The soil density ranges, in general, from very loose to dense. Sieve analyses were conducted on two samples: one from the 20- to 22-foot depth and one from the 25- to 27-foot depth in MW-7. The results are presented in Appendix C. These analyses confirm that the sediments in the saturated zone are predominantly medium to very coarse sand. Ground water was encountered while drilling at depths of approximately 10 to 16 feet below grade.

3.2 Monitoring Wells

Each monitoring well is constructed of a two-inch threaded black steel riser pipe attached to a two-inch No. 10 slot Johnson stainless steel continuous wrap screen, ten feet in length. The screens were located such that the top of the screen is at the water table. The wells are protected by four-inch locking protective casings and bumper posts. Complete well construction details are found in Appendix D. The monitoring wells were developed by surging, or withdrawing water from the well with a bailer until the ground water became free of sediment, a minimum of three well bore volumes evacuated, and ground water pH, temperature, and conductance stabilized. This development was performed prior to the February 10, 1989, sampling event for MW-1S, MW-2S, and MW-3S, and it was performed for MW-4S, MW-5S, MW-6S, and MW-7S prior to the June 22, 1989, sampling event.

3.3 Ground and Surface Water Measurements and Observations

Reference elevations are presented in Table 1 and ground water elevation data are presented in Table 2. Ground water is under unconfined conditions. Hydrographs for the Schloff wells are shown in Figure 6, and indicate that ground water is approximately 8 to 12 feet below the ground surface. In general, ground water levels increased from winter to spring of 1989 and have since decreased. Seasonally cyclic water table fluctuations are characteristic of shallow unconfined aquifers. Appendix E contains field ground water data sheets for recorded measurements.

Surface water measurement points were established at two locations on Minnehaha Creek. The locations are labeled as MC-1 and MC-2 on Figure 7. The elevations of the measuring points are listed in Table 3.

3.4 Ground and Surface Water Sampling

Ground water samples were collected from MW-1S, MW-2S, and MW-3S on February 10, 1989. All monitoring wells were sampled on June 22, 1989, September 8, 1989, and February 27, 1990. The abbreviations used throughout this report for these organic contaminants detected at the Schloff site are listed in Table 4. The results are summarized in Table 5. All samples were analyzed using EPA Test Method 601 for purgeable halocarbons. Sampling information forms and the laboratory analytical reports are found in Appendix F.

Surface water samples were collected from Minnehaha Creek at four locations on July 17, 1989. The sample collection locations (SW-1D, SW-2D, SW-3D, and SW-4D) are shown in Figure 7. Table 6 summarizes the results. All samples were analyzed using EPA Method 601 for purgeable halocarbons. The analytical results and sampling information forms are located in Appendix F.

3.5 Contaminant Observations

3.5.1 Soil Conditions

Unsaturated zone contaminant concentrations were investigated during drilling of wells MW-1S, MW-2S, and MW-3S with the use of an HNU Systems, Inc., Trace Gas Analyzer, Model PI 101. During the drilling of wells MW-4S, MW-5S, MW-6S, and MW-7S, a Thermo Environmental Instruments, Inc., Organic Vapor Monitor, Model 580A, was used to detect unsaturated zone contaminant concentrations. Both instruments are portable photoionization detectors (PID) with 10.2 eV lamps calibrated to a benzene standard. Two measurements were recorded with the PID. The first was the maximum concentration observed as the PID was passed directly over the split spoon immediately after opening. The second reading was a measurement of headspace concentrations in the sample jar after volatile organic gases escaping from the soil had equilibrated. Table 7 is a summary of split spoon sample and headspace monitoring data. PID readings were noted in the soil samples from MW-2S, MW-3S, and MW-4S.

Samples of soil were collected for laboratory analysis to verify field screening. Table 8 is a summary of the soil sample analytical results. Only samples from MW-3S, at 16 to 18 feet below grade, and MW-4S, at 18 to 20 feet below grade, show contaminant concentrations of PCE above the method detection limit (MDL). The MW-3S sample contained 330 parts per billion (ppb) PCE and the MW-4S sample, 200 ppb PCE. These soil samples were collected in the saturated zone of the surficial aquifer. The samples were analyzed using EPA Method 8010 for purgeable halocarbons. The laboratory analytical results and sampling information sheets are located in Appendix F.

3.5.2 Ground Water Conditions

Ground water analytical results indicate the presence of multiple chlorinated hydrocarbons in Schloff monitoring wells except MW-1S and MW-6S. Analytical results are summarized in Table 4. In general, MW-3S, located on site at the southeast corner of the Schloff property, has the highest levels of PCE, ranging over the period of sampling from 12,000 ppb on June 22, 1989, to 780 ppb on February 27, 1990. MW-4S and MW-2S, near the above ground tanks and FP-2, respectively, also contain high levels of PCE, with a range over the sampling period of 220 to 10,000 ppb. The levels of PCE in MW-5S and MW-7S ranged over the sampling period from 19 to 3600 ppb. The levels of 112TCE and 12DCE vary considerably over time in MW-2S, MW-3S, MW-4S, MW-5S, and MW-7S. Furthermore, MECL was detected sporadically in the same wells. 11DCE was detected at 0.6 ppb in MW-1S on September 8, 1989, and at 1.8 ppb in MW-7S on June 22, 1989. 111TCA was detected at 95 ppb in MW-3S on February 27, 1990; at 0.5 ppb in MW-5S on June 22, 1989; and at 0.6 ppb in MW-7S on June 22, 1989.

3.5.3 Surface Water Conditions

Chlorinated hydrocarbons were detected in all four samples collected from the creek; however, the samples collected at points SW-3D and SW-4D contained only MECL. Both SW-1D and SW-2D contained 12DCE, at 9.9 and 1.7 ppb, respectively (Figure 7). SW-1D contained 112TCE at 1.6 ppb. No PCE was detected in any of the surface water samples.

3.6 Slug Tests

Slug tests were performed on monitoring well MW-1S to determine the hydraulic conductivity of the aquifer materials. Slug tests indicate a hydraulic conductivity of approximately 6×10^{-2} feet per minute. Slug tests performed by CRA and summarized in the May 1987 report indicate hydraulic conductivities of 9×10^{-2} feet per minute. Slug test data and results are presented in Appendix G.

3.7 Pumping Test

3.7.1 General

A constant rate pumping test was performed on the surficial aquifer using the purge well (PW) described more fully in Section 5.0. The purpose of the test was to evaluate the aquifer characteristics and the effectiveness of contaminant plume capture. The location of the purge well is shown in Figure 5. The construction details for the well are in Appendix D. Table 9 lists the reference elevations for the pump on and off floats and the pump intake.

3.7.2 Field Methods

The test was initiated on January 17, 1990, and suspended on January 24, 1990. The total test duration was 7.1653 days (10,318 minutes). During the test, MW-3S and MW-7S were monitored electronically using a transducer and a Hermit 1000B datalogger (Hermit). In addition, the purge well, MW-1S, MW-2S, MW-5S, MW-6S, MW-7S, Minnehaha Creek at MC-1 and CDC wells MW-3, MW-B, and MW-C were monitored manually using electronic water level indicators. The Hermit and electronic water level indicator measure to the 0.01 foot. Drawdown versus time were recorded for all the monitoring points. Discharge water was treated and disposed to the sanitary sewer system. Aquifer test data field sheets used to record the pumping test data are included as Appendix H.

3.7.3 Observations

The pumping rate for the duration of the test was 53 gallons per minute (gpm) or 7.08 cubic feet per minute. Drawdown was noted in the purge well, MW-3S, MW-7S, and MW-5S, and to a lesser extent in MW-1S, MW-2S, and MW-4S. At a time between 1,488 and 10,318 minutes, the water level in the purge well reached the pump intake. Thus, drawdown at the purge well stabilized at the pump intake level 23 feet below the measuring point. At the completion of the test, MW-3S had 1.79 feet, MW-7S had 0.88 feet, MW-2S had 0.26 feet, and MW-4S had 0.11 feet of drawdown (Table 10). Figure 8 shows the zone of influence at approximately 10,300 minutes of the test, and Figure 9 depicts the drawdown at each monitored well. Background changes in the water table elevation appear to have been as much as 0.13 feet. This was evidenced in measurements from MW-4S and MW-6S, wells presumably least affected by pumping, collected at the end of the test (Table 2). The hydrographs, Figure 6, also indicate that the trend of naturally declining water table elevations would produce an overall background water table decline of about 0.1 to 0.2 feet.

3.7.4 Analysis

Data collected during the pumping test were evaluated to determine the transmissivity (T) and specific yield (S_y) of the aquifer. Two methods were used to perform the evaluation, the Jacob straight line method and the Theis curve matching method. Both time and distance drawdown evaluations were performed. The Jacob evaluation data and graphs are presented in Appendix I along with the Theis data and curves. Assumptions, calculations, and some discussion are also included. Table 11 is a summary of the pumping test results.

Jacob analysis of time and distance versus drawdown indicates a range of T from 2049 to 4436 feet squared per day (ft^2/day). Theis analysis indicates a range of T from 2406 to 4411 ft^2/day. Jacob analysis for S_y indicates a range of 0.014 to 0.205; Theis analysis indicates that S_y ranges from 4.7 x 10^{-4} to 0.31. An overview of the adherence of the various evaluation methods to assumptions inherent to the methods invalidates, or makes less valid, some of the evaluation results. The "best fit" T values for the site are 2,000 to 4,000 ft^2/day and S_y is in the range of 0.05 to 0.2.

The drawdown versus time curves for aquifer response at MW-3S, MW-2S, and PW indicate that drawdown deviates from that of the Theis and Jacob standard. The deviation is that expected when a no-flow boundary is encountered. Using image well theory and the Law of Times, the boundary location was determined (the calculations, assumptions, and some discussion are presented in Appendix J). The impermeable boundary appears to be beneath Minnehaha Creek (Figure 10). The result of this boundary is increased drawdown and capture in the area between PW and the creek.

4.0 DISCUSSION

4.1 Regional Hydrogeology

The regional hydrogeology consists of Pleistocene epoch (late Wisconsinian) Des Moines Lobe Deposits consisting of outwash sands, silty sand, and gravel; in places overlain by deposits of silt to clay loam two to four feet thick (Meyer, 1985). Minnehaha Creek, which meanders through the region, is controlled by the Gray's Bay dam. The stream likely has produced alluvial deposits along its current and former reaches.

4.2 Site Hydrogeology

Shallow ground water beneath the site is found within unconsolidated glacial outwash deposits. The deposits consist of at least 27 feet of fine to coarse grained sand. Figure 11 is a site map illustrating the locations of hydrostratigraphic cross sections presented as Figures 12 and 13. Generally, the water table is located from 8 to 12 feet below the ground surface, creating a saturated thickness in the surficial aquifer of 13 to 18 feet. The cross sections illustrate predominant lithologies encountered along with approximate water table positions. Based on information obtained from the CDC reports, this outwash unit extends to bedrock, which is encountered at about 75 feet below grade. Below approximately 30 feet, the silt content of the outwash increases and the gravel content decreases. This subdued transformation from permeable sands to less conductive silty-sands with depth forms a gradational contact between the surficial aquifer and the underlying lower water bearing sediments. Bedrock is Ordovician Plateville Limestone and the Glenwood Shale Formation. The Plateville Limestone is a gray, fractured and weathered, 10- to 12-foot thick unit that acts as a regional aquifer. The Glenwood Shale is a soft gray/green unit, usually less than 20 feet thick, which acts as a lower confining unit.

Surficial ground water flow in the vicinity of the site is towards the east-southeast as illustrated on Figures 14 and 15 (both figures use water level data obtained from CDC - PCO site during simultaneous monitoring events). The interplay of Minnehaha Creek and the surficial aquifer varies with the water table position relative to the stream flow level and the reach of the stream. The cross sections, Figures 12 and 13, illustrate the flow regimes for July 17, 1989, and January 17, 1990. At the time of the July 17, 1989, measurements, the flow in the aquifer in the area of MC-2 was to the stream (the hydrographs for the wells, Figure 6, indicate that this was a period of higher ground water elevation). Thus, the stream was a gaining stream at that time and in that area. In contrast, at the vicinity of MC-1, the flow was from the stream to the aquifer; thus, a losing stream. This correlates well with the Minnehaha Creek samples collected on July 17, 1989 (Table 6, Figure 7). No site specific contaminants were present in the samples until SW-1D and SW-2D, locations where flow is from the aquifer to the creek and where the plume intersects the creek.

At the time of the January 17, 1990, monitoring event, a different flow regime was present in the vicinity of MC-2. Ground water flow was away from the stream (the ground water hydrographs, Figure 6, indicate that ground water elevations were at their lowest point during this monitoring history). This scenario would cause a deflection of streamlines and contaminant migration pathways such that flow underneath the stream would not occur until ground water reached a point further downgradient. These varying stream and ground water interactions at this locality are likely the result of the rechanneling of Minnehaha Creek. West of MC-2, no ground water flow would occur directly southward beneath the stream due to the effects of the stream, and the creation of an impermeable barrier during rechannelization.

To attempt to understand this complex ground/surface water interaction and the role of the stream rechanneling, piezometers were installed into the base of the creek at the MC-2 location. Table 12 contains the results of this activity. Each piezometer was driven to a different depth below the surface of the streambed. Care was taken not to allow water in the creek to flow along the borehole of the pipe and, thereby, invalidate the measurements. Measurements were made from a common datum (the creek surface) to the top of ground water in the piezometer. As the depth of the piezometer increased, so did the depth to ground water. Evaluation of this data indicates that at the time of these measurements (May 31, 1989) a steep vertical gradient existed between the creek level and the water table. Furthermore, the magnitude of the measurements indicate that little flow occurs out the bottom of the stream in this location.

The well logs for MW-7S and MW-5S support the existence of lower permeability sediments, perhaps emplaced during channel reworking to impede streamflow loss. Well logs for MW-7S indicate that a black topsoil layer is present from 5 to 11 feet below grade; in MW-5S a silty clay layer was present from 8 to 14 feet below grade. These sediments, assuming they are somewhat continuous, are more likely than sand and gravel, to impede flow from the creek to the surficial aquifer. The presence of lower permeability sediments along the reaches of Minnehaha Creek is also supported by the pumping test evaluation. The low-flow boundary encountered during pumping was located at the stream.

The saturated thickness of the surficial outwash aquifer is about 13 to 18 feet. This calculation is based on the elevation data of the silty sand unit for CDC's MW-3 (about 870 feet) and the elevation of the bottom of PW (about 875 feet) and the water table elevation at PW (about 888 feet). Calculations are found in Appendix J.

The hydraulic gradient across the site (from MW-6S to MW-5S) ranges from 7.61×10^{-4} to 2.93×10^{-3} feet/foot with a mean value of 2.07×10^{-3} feet/foot. Calculations are found in Appendix J.

The hydraulic conductivity, observed from slug testing in MW-1S, is about 86 feet per day. Pumping test data indicates hydraulic conductivity ranging from 113 to 317 feet per day for the site (Table 11). These values are more representative than those derived from the slug test.

The average linear ground water flow velocity can be estimated by the following equation:

$$V = K\,i\,/\,n$$

where V is the average linear velocity, K is the hydraulic conductivity, i is the hydraulic gradient across the area of interest, and n is the sediment porosity. For the range of values listed above, and an assumed porosity of 30 percent, the calculated flow velocity ranges from 217 to 730 feet/year. Calculations are found in Appendix J.

The hydraulic gradient in the lower aquifer, based on information presented in the August 1989 Detailed Analysis Report (DAR) written by CRA, indicates flow is to the south. This data indicates that there is a westerly flow component in the lower aquifer in the northeast portion of the CDC monitoring well network. This is illustrated in Figure 1.7 of CRA's 1989 DAR.

4.3 Sources, Nature, and Extent of Contamination

4.3.1 Contaminant Nature

PCE, the only suspected source of organic contaminants at this site, is a synthetic compound. It is an extremely stable, colorless liquid that is used primarily as a dry-cleaning solvent and a metal degreaser. (Sexetal, 1987) Physiochemical properties of PCE and the other contaminants found at the Schloff site are listed in Table 13. In general, all these halogenated solvents are more dense, and less viscous than water; are not nearly as biodegradable as other organic compounds; are largely nonsorbing and, therefore, quite mobile; and, rather volatile (Schwille, 1988).

Environmental transformation plays a major role in the subsurface metamorphosis of the PCE in the ground water system. The transformation can occur by chemical reactions in solution, chemical reaction with soil constituents, and by microbial action. 112TCE and 12DCE (cis-12DCE and trans-12DCE are isomers and, thus, are expected to behave similarly) are common degradation products of PCE (Smith and Dagun, 1984). PCE degradation is the likely source of these chemicals on site. Figure 16 illustrates plausible alternatives for the transformation pathways for the chemicals found at the Schloff site. The mechanisms for such transformations are reductive dechlorination, hydrolysis, oxidation, or a combination of the three. The resulting degradation products actually observed in any case are a function of soil conditions, types of microorganisms present, pH, temperature, and other environmental factors. (Smith et. al., 1984)

Smith et. al., 1984 indicates that 11DCE is a degradation product of 111TCA. 111TCA was detected in MW-3S at 95 ppb on the February 27, 1990, sampling date, approximately one month after pumping of purge well PW. 111TCA was detected in the February 1989, PCE spill, and its origin could be as a contaminant in the grade of PCE used at the site, or from the contents of the transporter truck involved in the February 13, 1989, spill described below.

MECL is common laboratory reagent and frequently introduced in the laboratory. However, the presence of MECL in some monitoring wells is significant. While mostly used in paint stripping and solvent degreasing, MECL is also used as a refrigerant in low-pressure refrigerators and air conditioners (Verschueren, 1983).

4.3.2 Contaminant Sources

Two source areas are identified where spilled or leaked PCE may have contacted the environment (Figure 17). They are as follows:

1. The fill pipe accessed by the railroad spur (FP-1)
2. The fill pipe used by truck transport (FP-2).

The PCE tank area may have been impacted by PCE. The sand used to clean up small spills (Section 2.3) was placed inside the diked area. Rainfall would tend to leach the PCE from the sand and the resulting runoff may have leaked outside the diked area via the drain outlet located between the two tanks, at the base of the dike.

Spills in areas near FP-1 and FP-2 would result in direct impacts to the surficial soils and potentially the subsurface environment. Asphalt is present in the area near FP-2, however, its ability to impede infiltration of the spilled substance is questionable. Spills which occurred in these areas would either volatilize to the atmosphere, pool and be passively absorbed with sand, or infiltrate into the subsurface.

One documented spill exists for the area near FP-2. This spill took place on February 13, 1989, during unloading of PCE from the storage tanks to a 500-gallon transport truck. The spill occurred during operation of the site by Weinberg. At the time of this spill, the PCE was owned and under the control of the lessee. The transport truck, when it arrived on site, apparently contained as much as 200 gallons of liquid. The operator attempted to load 500 gallons of PCE into the already partially filled tank, resulting in a spill of 25 to 30 gallons of liquid (as estimated by the operator), in an unknown mixture of PCE and the prior contents of the truck. The impacted area of the spill is shown in Figure 17. The spilled area was treated with diatomaceous earth, which was scraped up and placed in six 50-gallon barrels. A sample of melt water in the spill area, collected by Delta after the clean-up attempt, was analyzed and found to contain 111TCA. Table 14 is the summary of the analytical results from that spill.

PID readings of the impacted area were 2 to 12 ppm. Copies of the original laboratory results, the chain-of-custody, and sampling information sheet are in Appendix F.

A prior reported spill occurred on October 1988, in the area of FP-2. This spill occurred during the unloading of a PCE shipment of Occidental Chemical corporation. It is believed that Occidental's pump valve malfunctioned, causing the spill, but this and the estimated quality of PCE released is still under investigation.

4.3.3 Ground Water Contamination Extent

The extent of surficial ground water contamination at the Schloff site is defined by ground water sampling data. Furthermore, correlation exists of the Schloff data with time similar data provided by CDC from the PCO site. Figure 18 depicts the inferred extent of PCE contamination in the surficial outwash aquifer. The inferred extent of contamination is based on data gathered June 22, 1989, by Delta and June 5, 1989, by CDC. The following observations are made:

- The likely source areas could include the tank area, and the fill pipe areas, FP-1 and FP-2.
- The mass center of the ground water contaminant plume exists around PW and MW-3S.
- The plume shape is narrow as would be expected in a high permeability environment (i.e., little or no lateral advection or dispersion).
- Correlation of plume dimensions and concentrations with the CDC data is good.
- Further control is needed in the monitoring well network to define the plume boundaries on the southern boundary, west of the Merit Gage building, and the eastern boundary, east of MW-5S.

Figure 19 is the inferred extent of the total volatile organic compound (VOC) concentration map for June 1989, generated using Schloff and CDC - PCO data. This map and data set represents a time-specific representation of a migrating ground water contaminant plume. The plume configurations of the PCE degradation products, 112TCE and 12DCE, have similar configurations to that of PCE.

Samples collected by Delta on February 27, 1990, are used to depict the inferred extent of PCE and total VOC plume configurations as shown in Figures 20 and 21. The plume configurations of the PCE degradation products, 112TCE and 12DCE, again have similar configurations.

Documentation of the lower aquifer ground water contamination exists only via the CDC - PCO monitoring well network. A review of the chemistry collected by CRA indicates that PCE has never been detected in MW-BL, the most proximal lower aquifer well to the Schloff site. Two detections of 12DCE were observed; one on October 23, 1987, and one on November 2, 1987, at 1.2 and 0.6 ppb, respectively. 12DCE has not subsequently detected in MW-BL. 12DCE is a breakdown product of PCE and 111TCA. The current PCE plume in the lower aquifer appears, based upon flow direction and concentration gradients, not to originate at the Schloff site. Ground water flow in the lower aquifer appears to be northeast to southwest at the CDC - PCO site.

5.0 INTERIM RESPONSE ACTION IMPLEMENTATION AND OPERATION

5.1 Overview

An interim remedial action was implemented to capture the target compounds (PCE, 112TCE, and 12DCE) at the site. The interim action consists of a ground water purge well, underground piping, and a pretreatment system. Treated ground water is deposited via gravity drain into the sanitary sewer manhole located on site.

5.2 Ground Water Extraction and Zone of Influence

Ground water is extracted through the purge well labelled PW on Figure 5. The well is 27 feet deep and is constructed of 8-inch diameter black steel with a 10-foot long well screen. The system is designed to operate continuously at approximately 50 gpm. The well construction details are included in Appendix D.

Zone of influence of the purge well analysis was performed using capture zone equations and the pumping test drawdown data. The capture zone equations for a single well, as described in Bear (1979) and McWorter et. al., were used to calculate the predicted zone of influence of the well. Figure 22 shows the calculated zone of influence for the static (prepump) hydraulic gradient, the pumping rate, and for the range of transmissivity representative for the Schloff site. The calculations and discussion of assumptions are in Appendix J. To the south of PW, probably adjacent to the creek, is an impermeable hydraulic boundary (Figure 10). This distinctly alters the zone of influence and water table drawdown between the purge well and the creek. More drawdown is observed between the purge well and creek, due to the location of the impermeable boundary. As a result, enhanced capture in the horizontal and vertical planes occurs. This amplifies the affect of the pumping system at the potential source (FP-1 and FP-2) areas northwest of the purge well. Furthermore, the boundary prevents migration of contaminants to the south as flowlines are deflected to the east. Additional deflection of flowlines occurs when Minnehaha Creek is a losing stream; however, because of the relatively impermeable stream base, this deflection is likely not as drastic.

The area north of the creek is predicted quite accurately using the capture zone calculations. Comparison of Figures 9 and 22, the total drawdown at the end of the test and the calculated zones of influence, indicates that the zone of influence calculation for a transmissivity closer to 4000 ft^2/day is most representative.

5.3 Ground Water Collection and Treatment System

Ground water extracted from the recovery well is pumped to the treatment system located in the Schloff building (Figure 23). A pitless adapter was installed to connect the pipe attached to the pump to a two-inch diameter forcemain constructed of PVC. The forcemain, which is shown on Figure 23, is buried beneath the parking lot at a depth ranging from five to six feet below grade.

The discharge line from the treatment system consists of four-inch diameter PVC piping that is sloped to provide gravity flow. This line, shown on Figure 23, is buried beneath the parking lot at a depth ranging from five feet near the building, to seven feet at the discharge point. Treated ground water is discharged from the gravity drain to the on-site sanitary sewer manhole.

The water discharged to the sanitary sewer under a Metropolitan Waste Control Commission (MWCC) special discharge permit is ultimately treated at the Pig's Eye facility in St. Paul. Schloff has submitted a National Pollutant Discharge Elimination System (NPDES) permit application to discharge to Minnehaha Creek. That application was submitted on March 29, 1990, to the MPCA, Division of Water Quality.

5.4 Ground Water Pretreatment System

5.4.1 Layout and Operation

Figure 24 is a plan view of the diffused air treatment system that is used to pretreat the ground water prior to discharge to the sanitary sewer system. The system consists of two treatment vessels connected in series. Baffles were installed in the vessels to provide for plug flow. A centrifugal blower is connected to slotted, lateral aeration pipes that are placed along the bottom of the vessels. The bubbling and agitation of the water results in the stripping of the target compounds to acceptable discharge levels. The compounds removed from the water are emitted to the atmosphere through an eight-inch exhaust stack (Figure 25). The exhaust stack extends through the roof of the warehouse (Figure 26). A condensate tank at the stack discharge point (Figure 27) catches condensate and entrained water droplets and transports the fluid back to the tanks.

5.4.2 System Efficiency

Treatment system influent and effluent water samples were collected on January 15, 1990, prior to system startup, and on January 16 and February 27, 1990. These samples were collected to document performance of the system. At the time the samples were collected, the system was treating water at a rate of 53 gpm. The air flow rate through the system was measured at approximately 1,130 cubic feet per minute (cfm).

Table 15 lists VOC removal performance data obtained through sampling of the system influent and effluent. The system removes greater than 99 percent of the compounds present in the influent, which corresponds to discharge levels well below the limits specified in the MWCC permit.

Table 16 presents the results of sampling of the system effluent on January 16, 1990, for inorganic parameters. This sampling was completed to comply with MWCC permit requirements. No concentration exceeds the limits set forth by MWCC. The laboratory analytical report, the chain of custody, and the sampling information forms are included in Appendix F.

5.4.3 Air Discharges

The MPCA's Division of Air Quality was contacted during the design phase. An MPCA form entitled "Request for Environmental Impact Analysis of Remedial Action (RA)" was completed and submitted on

August 22, 1989. The MPCA has been apprised of the results of the calculations presented in the following sections.

5.4.3.1 Mass Discharged

The mass of compounds discharged per day through the stack is estimated from the effluent and influent data. Calculating the mass of dissolved organic compounds removed (influent levels minus effluent levels for a specific sampling event) and the flow rate of water through the treatment system, the discharge rate to the atmosphere, expressed in pounds per day, was calculated (Table 15). The corresponding air discharge rates for the compounds detected are 1.1 to 2.3 pounds per day (lbs/day) of PCE, 0.04 to 0.1 lbs/day of 112TCE, 0.2 to 0.3 lbs/day of 12DCE, and 0.07 lbs/day of MECL (MECL observed above detection limits for February 27 sampling date only).

5.4.3.2 Concentrations of Compounds in the Air

The concentrations of the target compounds in air discharged to the atmosphere from the pretreatment system are estimated as follows:

$$\text{Air concentration (ppm)} = \frac{\text{Liters of gas}}{\text{Liters of air}}$$

Parameters input into the equation are mass removed (moles), influent flow rate, and air flow rate. It is assumed that one mole of gas will occupy approximately 22.4 liters at standard temperature and pressure (basis for the ideal gas law). The corresponding concentrations of target compounds in the air discharged from the stack are 0.21 to 0.42 ppm of PCE, 0.01 ppm of 112TCE, 0.06 to 0.09 ppm of 12DCE, and 0.03 ppm of MECL (Table 17).

5.5 Maintenance and Monitoring

5.5.1 Monitoring Wells and Stream

Table 18 lists the proposed schedule for all monitoring at existing monitoring points at the Schloff site during 1990. Water samples will be collected quarterly from the monitoring wells and at the four stream sampling points shown on Figure 7. All samples will be collected and analyzed using EPA Method 601 for purgeable halocarbons. Water table and stream elevations will be measured during monthly site visits at all monitoring wells, at the stream gages, and at the purge well.

5.5.2 Treatment System

Monthly site visits will be performed to ensure proper operation of the extraction and treatment system. The treatment system effluent will be sampled quarterly using EPA Method 601 for purgeable halocarbons and for total dissolved solids, chemical oxygen demand, and pH. The system influent will be analyzed quarterly for purgeable halocarbons.

6.0 METHODS AND PROCEDURES

6.1 Soil Sampling, Classification, and Screening

Soil sampling is done in accordance with ASTM:D 1586-84. Using this procedure, a two-inch O.D. split barrel sampler is driven into the soil by a 140-pound weight falling 30 inches. After an initial set of six inches, the number of blows required to drive the sampler an additional 12 inches is known as the penetration resistance, or the "N" value. The N value is an index of the relative density of cohesionless soils and the consistency of cohesive soils.

As the samples are obtained in the field, they are visually and manually classified by the crew chief in accordance with ASTM:D 2488-84. Representative portions of the samples are then returned to the laboratory for further examination and for verification of the field classification. Logs of the borings indicating the depth and identification of the various strata, the N value, water level information, and pertinent information regarding the method of maintaining and advancing the drill hole are made.

Soil samples recovered from the split-spoon samples are screened immediately using an PID to determine the relative contamination of the sample. A portion of the split spoon sample is then collected and stored in a clean glass jar for soil vapor headspace measurements and lithologic description. The MPCA "Interim Recommendations, Jar Headspace Analytical Screening Procedures" is used to conduct headspace measurements. The collection of soil vapor headspace measurements involves sealing the jar mouth with aluminum foil and capping the jar. After the boring is completed and the samples have equilibrated to similar temperatures, the cap is removed from the jar and the aluminum foil is punctured with the PID probe. This allows for the measurement of volatile organic vapors which may have accumulated in the headspace of the sample jar.

6.2 Monitoring Well Installation

All monitoring wells are constructed and installed in accordance with current Minnesota Department of Health Water Well Code regulations by a contractor licensed within the state of Minnesota. Monitoring wells consist of two-inch I.D. steel casings and screens. The borehole annulus from the bottom of the boring to a point approximately one foot above the top of the screen is backfilled with clean, medium grained sand or an approved alternate. The remaining borehole annulus is backfilled with cement/bentonite grout to the surface. The portion of the riser pipe exposed above the ground surface is protected with a 4-inch diameter by 5-foot (approximate) long lockable steel casing, terminating approximately 2.5 feet above the ground surface. All screens are 0.010 slot continuous wrap, Johnson stainless steel screens. The top of the screen was set at the water table as it was encountered during drilling.

6.3 Ground Water and Stream Level Measurements

All ground water level measurements are obtained by using an electronic measuring device that indicates when a probe is in contact with ground water in the well. Measurements are obtained by lowering the probe into the well until the device indicates that the water surface is encountered and by measuring the distance from the reference point, usually the top of the riser pipe, to the probe. All of the measurements are recorded to the nearest 0.01 foot.

The procedure for measuring stream levels is similar. The probe is lowered until the device indicates the probe is at the stream surface. A reference point is used to determine the elevation of the stream surface. If ice is present on the stream surface, a measurement is collected only if the ice can be removed.

After each measurement, the probe and cable of the measuring device are cleaned with a deionized water, denatured alcohol, and deionized water rinse.

6.4 Water Sampling

6.4.1 Monitoring Wells

Monitoring wells are sampled from the suspected cleanest to the most contaminated. The following describes the protocol for sampling a monitoring well.

Field Protocol

Step 1: Measure the water level.

Step 2: Develop the monitoring well with a dedicated bailer. A minimum of three to five well bore water volumes are evacuated from the monitoring well. After each bore volume, pH, temperature, and specific conductivity measurements are made to determine if the ground water is stabilized. Two successive readings with little or no deviation indicate ground water stabilization.

Step 3: Collect water samples. Water samples are collected using a dedicated stainless steel bailer.

Step 4: Water samples are stored and transported to the specified laboratory, following all documentation, preservation, and chain of custody procedures.

Step 5: Clean the equipment. Water level measurement equipment is cleaned with denatured alcohol and deionized water rinse.

6.4.2 Stream Water Sampling

The sampling procedures for collecting Minnehaha Creek samples is as follows:

- Wade to the center and/or deepest part of the stream at the point of sample collection.
- Allow sediment to settle while standing facing upstream.
- remove lid when vial is at collection depth. ?
  Remove the lid from the sample vial and immerse the vial in the stream to a point half the distance between the surface and bottom of the stream.
- Fill and cap the vial prior to removal from the stream.
- Check for the presence of air bubbles in the vial; if present, repeat the above procedure.

6.4.3 Sampling Documentation Procedures

Upon completion of a soil, ground water, or stream water sampling event, a chain of custody record is initiated. Chain of custody records include the following information: project name and location, project number, shipped by, shipped to, suspected hazard, sampling point and location, field identification number, date and time collected, sample type, number of containers, analysis required, and the sampler's signature. As few people as possible handle the samples.

The chain of custody records are shipped with the samples to the laboratory. Upon arrival at the laboratory, the sample is checked in by the appropriate laboratory personnel. Laboratory identification numbers are noted on the chain of custody record. A copy of the chain of custody is turned over to the laboratory project manager. Upon completion of the laboratory analysis, the completed chain of custody record is returned to the Delta project manager.

6.5 Slug Test

The purpose of a slug test is to determine the in-situ hydraulic conductivity of the aquifer materials. The test is initiated by causing an instantaneous change in the water level in a monitoring well through a sudden introduction or removal of a slug of known volume.

The method of analysis of slug test data is a function of the well configuration, aquifer type, and the position of the water table relative to that of the screen. The following data analysis methods are employed as appropriate:

- Bouwer and Rice (1976)
- Bouwer (1989)
- Cooper et al(1967)
- Hvorslev (1951)
- Papadopulos et al (1973)
- Thompson (1987)

These methods are referenced in the following:

Bouwer, H. and R.C. Rice. 1976. A slug test for determining the hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research, Vol. 12, pp. 423-428.

Bouwer, H. May-June 1989. The Bouwer and Rice slug test - an update. Ground Water, Vol. 27, No. 3, pp. 304-309.

Cooper H.H., Jr., J.D. Bredehoeft, and I.S. Papadopulos. 1967. Response of a finite diameter well to an instantaneous charge of water. Water Resource Research, Vol. 3, pp. 263-269.

Hvorslev, M.M. 1951. Time log and soil permeability in ground water observations. U.S. Army Corps Engineers. Waterway Exp. Sta. Bull. 36, Vicksburg, Miss.

Papadopulos, I.S., J.D. Bredehoeft, and H.H. Cooper. 1973. On the analysis of slug test data. Water Resources Research, Vol. 9, pp. 1087-1089.

Thompson, D.B. 1987. A microcomputer program for interpreting time-log permeability tests. Ground Water, Vol. 25, No. 2, pp. 212-218.

6.6 Surveying

All monitoring well measuring points and ground level references and stream gages were surveyed to the nearest 0.01 foot using the USGS benchmark located at the south end of the east bridge buttress at Minnehaha Creek and Meadowbrook Road. The benchmark elevation is 901.28 feet.

7.0 REMARKS

The recommendations contained in this report represent our professional opinions. These opinions are based on currently available information and are arrived at in accordance with currently accepted hydrogeologic and engineering practices at this location. Other than this, no warranty is implied or intended.

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Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals, Second Edition. Van Nostrand Reinhold Company, Inc.

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McWorter, D.B. and D.K. Sunada. 1977. Ground Water Hydrogeology and Hydraulics, Colorado State University, Ft. Collins, CO.

TABLE 1

Monitoring Well Reference Elevations
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Well No.	Ground Elevation	Top of Casing Elevation	Top of Screen Elevation	Bottom of Screen Elev.	Screen Length	Screen midpt
MW-1S	904.26	906.86	888.27	878.27	10	
MW-2S	902.68	905.03	890.68	880.68	10	885.68
MW-3S	901.96	904.13	887.96	877.96	10	
MW-4S	902.55	904.40	888.45	878.45	10	
MW-5S	896.73	898.65	884.03	874.03	10	
MW-6S	899.71	901.66	885.41	875.41	10	
MW-7S	901.89	903.85	884.29	874.29	10	879.29
PW	902.11	904.11	884.94	874.86	10	

All units are in feet.

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TABLE 2

Ground and Surface Water Elevation Summary
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

	Gaining	Gaining	Gaining	Gaining	Gaining	Losing?	Losing?	Gaining		Losing			
	2/10/89	4/19/89	5/11/89	5/31/89	6/21/89	7/17/89	8/10/89	9/08/89	1/16/90	1/17/90(1)	1/18/90(2)	1/24/90(2)	2/27/90
MW-1S	888.21	888.97	889.26	889.26	889.01	888.90	888.81	888.89	887.90	887.85	887.84	887.48	887.84
MW-2S	888.80	889.25	889.67	889.51	889.31	889.15	889.10	889.23	888.72	888.70	888.63	888.44	888.51
MW-3S	887.75	888.49	888.78	888.70	888.44	888.33	887.19	888.42	887.44	887.49	886.25	885.70	887.21
MW-4S	---	---	---	---	889.55	889.41	889.37	889.47	888.81	888.79	888.77	888.68	888.68
MW-5S	---	---	---	---	888.38	887.87	887.85	888.19	886.95	886.90	886.84	886.57	886.77
MW-6S	---	---	---	---	889.74	889.64	889.58	888.71	---	888.90	888.91	888.81	888.88
MW-7S	---	---	---	---	888.43	888.28	888.15	888.34	887.57	887.57	887.07	886.69	887.45
MW-3	887.46	---	---	---	---	888.06	---	---	---	887.04	---	---	---
MW-B	887.21	---	---	---	---	887.93	---	---	---	886.80	---	---	---
MW-C	866.94	---	---	---	---	887.84	---	---	---	886.56	---	---	---
MW-5	886.38	---	---	---	---	887.64	---	---	---	---	---	---	---
MW-D	886.60	---	---	---	---	887.65	---	---	---	---	---	---	---
MW-4	885.59	---	---	---	---	887.07	---	---	---	---	---	---	---
MW-2	885.58	---	---	---	---	886.65	---	---	---	---	---	---	---
MW-1	885.59	---	---	---	---	886.70	---	---	---	---	---	---	---
MW-A	886.78	---	---	---	---	887.59	---	---	---	---	---	---	---
PW1	---	---	---	---	---	887.96	---	---	---	---	---	---	---
MC1	---	897.86	---	---	---	891.95	891.94	895.59	---	---	---	---	---
MC2	888.27	888.17	888.42	888.27	888.02	887.98	887.91	888.06	---	887.91	---	---	---
PW	---	---	---	---	---	---	---	888.41	887.42	887.54	882.04	883.17	887.29

Units are in feet.
Pumping from PW began at 12:31 p.m. on January 17, 1990, and continued through January 24, 1990.
(1) Measurements collected just prior to pump test initiation.
(2) Measurements collected during pumping.
Pump was down during February 27, 1990, measurements.
- - - Elevations not measured.

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TABLE 3

Minnehaha Creek Reference Elevations
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Location	Measuring Point Elevation	Notes
MC-1	910.26	At railroad bridge west of site.
MC-2	902.73	At bridge on Meadowbrook road.

All units are feet.

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TABLE 4

Abbreviations
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Chemical Name	Abbreviation
1,1,2,2-Tetrachloroethylene	PCE
1,1,1-Trichloroethane	111TCA
1,1,2-Trichloroethylene	112TCE
trans- and cis-1,2-Dichloroethylene	12DCE
Methylene chloride	MECL
1,1-Dichloroethylene	11DCE
1,1-Dichloroethane	11DCA

For this report, 12DCE represents the total of cis-1,2-Dichloroethylene and trans-1,2-Dichloroethylene.

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TABLE 5

Ground Water Analytical Results
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Date:	2/10/89	6/22/89	9/08/89	2/27/90
Well I.D.		Concentration		
MW-1S				
PCE	ND (1.0)	ND (1.0)	ND (1.1)	ND (1.0)
112TCE	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
12DCE	ND (0.5)[3]	ND (0.5)[3]	ND (0.3)	ND (0.3)[3]
MECL	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
11DCE	ND (0.3)	ND (0.3)	0.6	ND (0.3)
MW-2S				
PCE	2600	2200[1]	9400[2]	220
112TCE	250	83	ND (120)	52
12DCE	1000[3]	ND (15)[3]	140[3]	150[3]
MECL	ND (100)	540	ND (250)	39
MW-3S				
PCE	1000	12000	1000	780
112TCE	180	ND (50)	43	ND (50)
12DCE	50[3]	ND (30)[3]	17[3]	230[3]
MECL	ND (50)	300	49	420
111TCA	ND (25)	ND (50)	ND (120)	95
MW-4S				
PCE	---	9000	10000	260
112TCE	---	ND (50)	ND (100)	ND (10)
12TCE	---	ND (30)[3]	ND (60)[3]	7.8[3]
MECL	---	ND (100)	ND (200)	30
MW-5S				
PCE	---	35	19	2100
112TCE	---	1.5	ND (0.5)	ND (100)
12DCE	---	ND (0.3)[3]	ND (0.3)[3]	ND (60)[3]
MECL	---	1.4	1.5	420
111TCA	---	0.5	ND (0.5)	ND (100)

Well I.D.		Concentration		
MW-6S		6/22/89	9/8/89	2/27/90
PCE	---	1.5	ND (1.0)	ND (1.0)
112TCE	---	ND (0.5)	ND (0.5)	ND (0.5)
12DCE	---	ND (0.3)[3]	ND (0.3)[3]	ND (0.3)[3]
MECL	---	ND (1.0)	ND (1.0)	ND (1.0)
MW-7S				
PCE	---	3600	1800	680
112TCE	---	240	130	110
12DCE	---	1.5	270[3]	3000[3]
111TCA	---	0.6	ND (25)	ND (50)
11DCE	---	1.8	ND (50)	ND (30)
MECL	---	ND (1.0)	ND (50)	110

(1) 1,2-Dichloropropane detected in MW-2 ground water at 17 ppb on June 22, 1989.
(2) Sample collected on September 11, 1989.
(3) Because of coeluting peaks, this value represents the total of cis-1,2-dichloroethylene and trans-1,2-dichloroethylene.

--- No sample collected.
Units = Parts per billion (ppb).

The value listed in parentheses is the method detection limit.

ND - Not detected at or above the method detection limit.

kmf.517

TABLE 6

Surface Water Analytical Results
Samples Collected July 17, 1989
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Location		Concentration
SW-1D	MECL	2.7
	12DCE	9.9
	12TCE	1.6
	PCE	ND (1.0)
SW-2D	MECL	ND (1.0)
	12DCE	1.7
	112TCE	ND (0.5)
	PCE	ND (1.0)
SW-3D	MECL	1.2
	12DCE	ND (0.3)
	112TCE	ND (0.5)
	PCE	ND (1.0)
SW-4D	MECL	2.4
	12DCE	ND (0.3)
	112TCE	ND (0.5)
	PCE	ND (1.0)

Units - parts per billion (ppb).
ND - Not detected at or above the method detection limit.
The value listed in parentheses is the method detection limit.

kmf.517

TABLE 7

Soil Vapor Monitoring
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

MW-1S

Sample Interval	Split Spoon	Head Space
0 - 2	0	<1
2 - 4	0	<1
4 - 6	0	<1
6 - 8	0	<1
8 - 10	0	<1
10 - 12	0	<1
12 - 14	0	<1
14 - 16	0	<1
16 - 18	0	<1(1)
18 - 20	0	<1
20 - 22	0	<1
24 - 26	0	<1

MW-2S

Sample Interval	Split Spoon	Head Space
0 - 2	10	>200
2 - 4	8	10
4 - 6	8	12
6 - 8	6	4
8 - 10	10	15(1)
10 - 12	- -	30
12 - 14	1	12
14 - 16	0	30
16 - 18	0	<1
18 - 20	1	5
20 - 22	0	<1

MW-3S

Sample Interval	Split Spoon	Head Space
0 - 2	0	3
2 - 4	0	4.5
4 - 6	0	5
6 - 8	0	3
8 - 10	0	2
10 - 12	0	1
12 - 14	0	2
14 - 16	<1	6
16 - 18	<1	7(1)
18 - 20	0	13
20 - 22	0	8
22 - 24	0	2

MW-4S

Sample Interval	Split Spoon	Head Space
0 - 2	--	--
2 - 4	8	10
4 - 6	37	20
6 - 8	36	47
8 - 10	50	71
10 - 12	0(1)	31
12 - 14	19	70
14 - 16	--(2)	--(2)
16 - 18	0	10
18 - 20	0	4(1)
20 - 22	0	8
22 - 24	0	14

MW-5S

Sample Interval	Split Spoon	Head Space
0 - 2	--	--
2 - 4	0	0
4 - 6	0	0
6 - 8	0	0
8 - 10	0	0
10 - 12	0	0
12 - 14	0	0
15 - 17	0	0(1)
20 - 22	0	0

MW-6S

Sample Interval	**Split Spoon**	**Head Space**
0 - 2	--	--
2 - 4	0	0
4 - 6	0	0
6 - 8	0	0
8 - 10	0	0
10 - 12	0	0
12 - 14	0	0
14 - 16	0	0
20 - 22	0	0

MW-7S

Sample Interval	**Split Spoon**	**Head Space**
0 - 2	--	--
2 - 4	0	0
4 - 6	0	0
6 - 8	0	0
8 - 10	--(1)	--(1)
10 - 12	0	0
12 - 14	0	0
14 - 16	--	--
20 - 22	0	0
25 - 27	0	--

(1) Sample collected for laboratory analysis.
(2) Little or no recovery.
All PID readings are ppm with the PID calibrated to benzene.

kmf.517

TABLE 8

Soil Sample Analytical Results
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Location	Depth	Parameter	Concentration
MW-1S	16 - 18	All	ND
MW-2S	8 - 10	All	ND
MW-3S	16 - 18	PCE	330
MW-4S	18 - 20	PCE	200
MW-5S	15 - 17	All	ND

Units - parts per ~~m~~billion (ug/kg).
All samples analyzed for EPA method 601.
All other 601 parameters not detected, at or above the method detection limit.
ND - Not detected at or above the method detection limit.

kmf.517

TABLE 9

Pump Intake and Float Settings
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

	Depth Below Measuring Point	Elevation
Intake	23.0	881.11
Pump-On Float	17.50	886.61
Pump-Off Float	22.75	881.36

All units are in feet.
Measuring point elevation is 904.11 feet.

kmf.517

TABLE 10

Drawdown at 10,300 Minutes
After Pumping Started
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

MW-1S	0.37
MW-2S	0.26
MW-3S	1.79
MW-4S	0.11
MW-5S	0.33
MW-6S	0.09
MW-7S	0.88
PW	4.37

All units are in feet.

kmf.517

TABLE 11

Pump Test Evaluation Summary
Surficial Outwash Aquifer
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Test Date: January 17, 1990

Pump Rate: 53 gpm (7.08 ft^3/min = 10,195 ft^3/day)

Well No.	Distance From Purge Well (ft)	T (ft^2/day) (Jacob)	T(ft^2/day) (Theis)	S_y (Jacob)	S_y (Theis)	T (ft^2/day) (Slug Test)
MW-7S	140	4096(1)	3877	0.048(1)	0.058	--
Purge Well	0.25	2396(2)	2406(2)	0.082	0.31	--
MW-2S	276	7281(1)	4411	0.15(1)	0.27	--
MW-3S	46	2544-4020(1),(2) 4436(3)	25131(2)	0.014-0.069(1)	$4.7X10^{-4}$	--
MW-1S	--	--	--	--	--	1059
Distance Drawdown t = 10,000 minutes	--	2049	--	0.205	--	--

--- Analysis not performed.
(1) Not valid due to violation of method assumption.
(2) Break in slope indicative of impermeable boundary; early data used.
(3) Based on Lohman evaluation.

kmf.413

TABLE 12

Minnehaha Creek Piezometer Measurements
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

May 31, 1989

	Depth of Water Table Below Stream level	Depth of Opening below Stream Level
MP-1	1.12	2.0
MP-2	0.11(1)	4.0
MP-3	2.23	5.0

(1) Piezometer pipe was bent during installation. Likely there was leakage.
All units are in feet.

kmf.517

TABLE 13

Contaminant Properties
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

	Chemical Formula	Molecular Weight	Boiling Point	Vapor Pressure	Specific Gravity	Water Solubility	K_{oc}	Relative Mobility
PCE	C_2Cl_4	165.85	121.2	19	1.623	150	364	Medium
112TCE	C_2HCl_3	131.40	86.7	77	1.46	1100	126	Medium
trans 12DCE	$C_2H_2Cl_2$	96.95	47	265	1.26	600	59	Low
cis 12DCE	$C_2H_2Cl_2$	96.95	60	208	1.28	800	---	---
MECL	CH_2Cl_2	84.93	40	349	---	16,700	---	Very high
11DCE	$C_2H_2Cl_2$	96.95	31.5	500	1.21	250	65	Low
111TCA	$C_2H_3Cl_3$	133.41	74	100	1.35	4400	152	Medium
Units:			°C	mmHg		mg/L at 25°C	ml/g	

K_{oc} - Sediment/water partition coefficient (after Schwille, 1988).

kmf.517

TABLE 14

Spill Analytical Results Summary
Sample Collected on February 13, 1989
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Parameter	MDL	Concentration
11DCE	7.5	45
11DCA	5.0	180
111TCA	12	970
PCE	25	700

Units - ppb.
Analyzed for EPA Method 601 parameters.
All other parameters not detected at or above the method detection limit.
MDL - Method detection limit.

kmf.517

TABLE 15

Treatment System Influent and Effluent
Analytical Results Summary
Organic Chemicals
Samples Collected January 16, 1990
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Compound	Date	Influent (ug/l)	Effluent (ug/l)	Removed Efficiency (%)
PCE	1/15/90	3600	2.1	99.9
TCE	1/15/90	160	ND (<0.5)	99.7
12DCE	1/15/90	330	0.9	99.7
PCE	1/16/90	3500	2.6	99.9
TCE	1/16/90	67	ND (<0.5)	99.2
12DCE	1/16/90	290	2.1	99.3
PCE	2/27/90	1800	ND (<1.0)	99.9
TCE	2/27/90	130	ND (<0.5)	99.6
12DCE	2/27/90	450	ND (<0.3)	99.9
MECL	2/27/90	110	ND (<1.0)	99.1

Units - ppb.
ND - Not detected at or above the method detection limit.
The value listed in parentheses is the method detection limit.

kmf.517

TABLE 16

Treatment System Influent and Effluent
Analytical Results Summary
Inorganic Chemicals
Samples Collected on January 16, 1990
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Parameters	Influent Concentration	Effluent Concentration	Permit Limits
Cadmium	--	ND (0.01)	2.0
Chromium (total)	--	ND (0.1)	8.0
Copper	--	ND (0.01)	6.0
Lead	--	ND (0.1)	1.0
Cyanide (total)	--	ND (0.01)	4.0
Nickel	--	ND (0.05)	6.0
Zinc	--	ND (0.1)	8.0
pH	7.5	8.0	5.0 - 10.0
COD	ND (50)	ND (50)	500
TSS	--	ND (1)	250
Calcium	60	59	NA
Total Hardness	250	250	NA
Magnesium	24	24	NA
Manganese	0.19	0.19	NA
TDS	400	400	NA

Units - ppm.
ND - Not detected at or above the method detection limit.
The value listed in parentheses is the method detection limit.
NA - Not applicable.
-- - Not sampled for.

kmf.517

TABLE 17

Air Concentrations
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Compound	Date	Removal Rate (lb/day)	Air Concentrations (ppm)
PCE	1/15/90	2.3	0.42
TCE	1/15/90	0.1	0.01
T12DCE	1/15/90	0.2	0.06
PCE	1/16/90	2.2	0.42
TCE	1/16/90	0.04	0.01
T12DCE	1/16/90	0.2	0.06
PCE	2/27/90	1.1	0.21
TCE	2/27/90	0.08	0.01
T12DCE	2/27/90	0.3	0.09
MECL	2/27/90	0.07	0.03

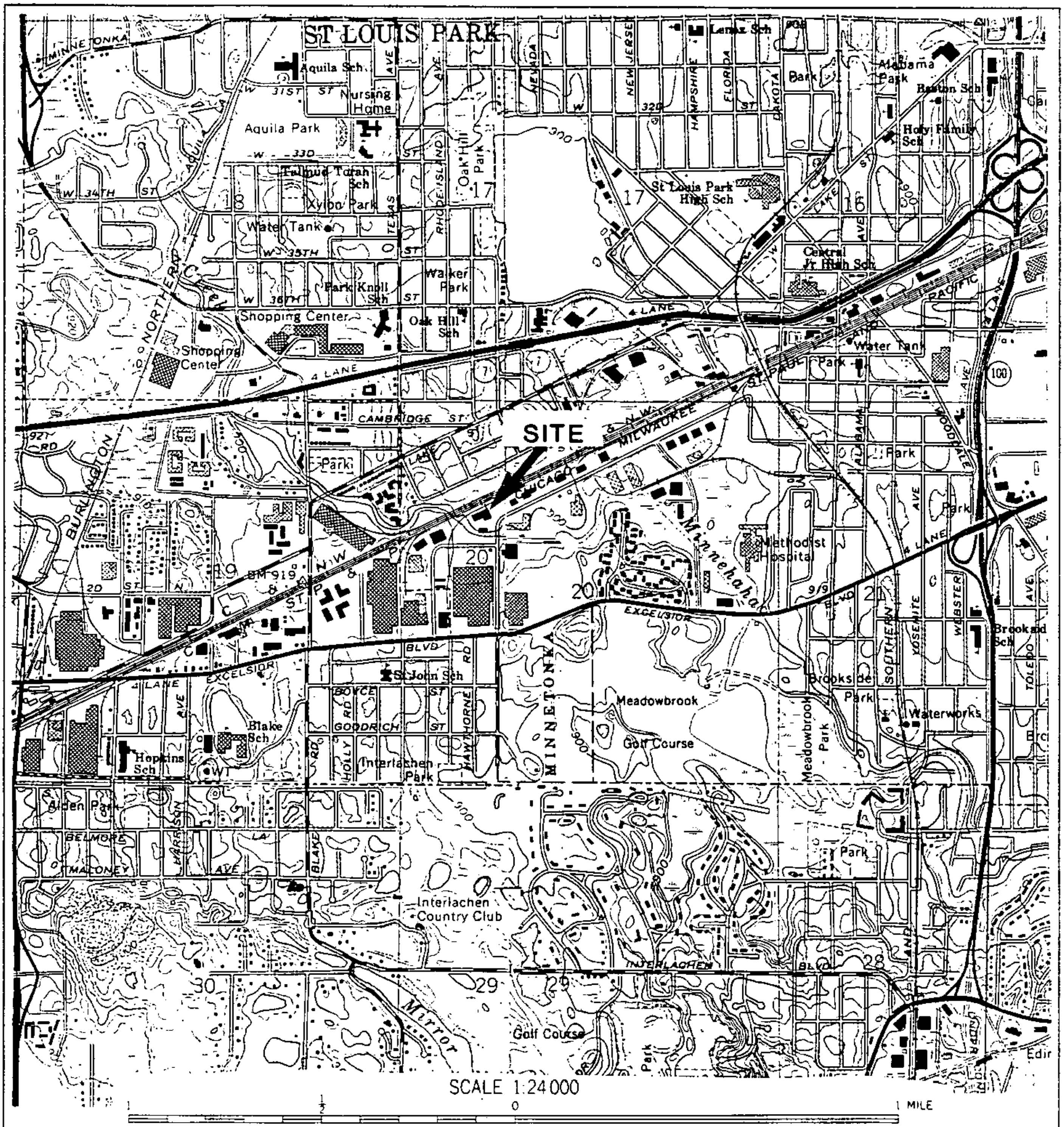
kmf.517

TABLE 18

Monitoring Schedule - 1990
Schloff Chemical Company
St. Louis Park, Minnesota
Delta No. 10-88-706

Water Levels	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Monitoring Wells	X	X	X	X	X	X	X	X	X
Purge Well	X	X	X	X	X	X	X	X	X
Stream	X	X	X	X	X	X	X	X	X
Sampling									
Monitoring Wells	X		X			X			X
System Effluent	X		X			X			X
System Influent	X		X			X			X
Stream	X		X			X			X

kmf.517



HOPKINS QUADRANGLE
MINNESOTA–HENNEPIN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

HOPKINS, MINN.

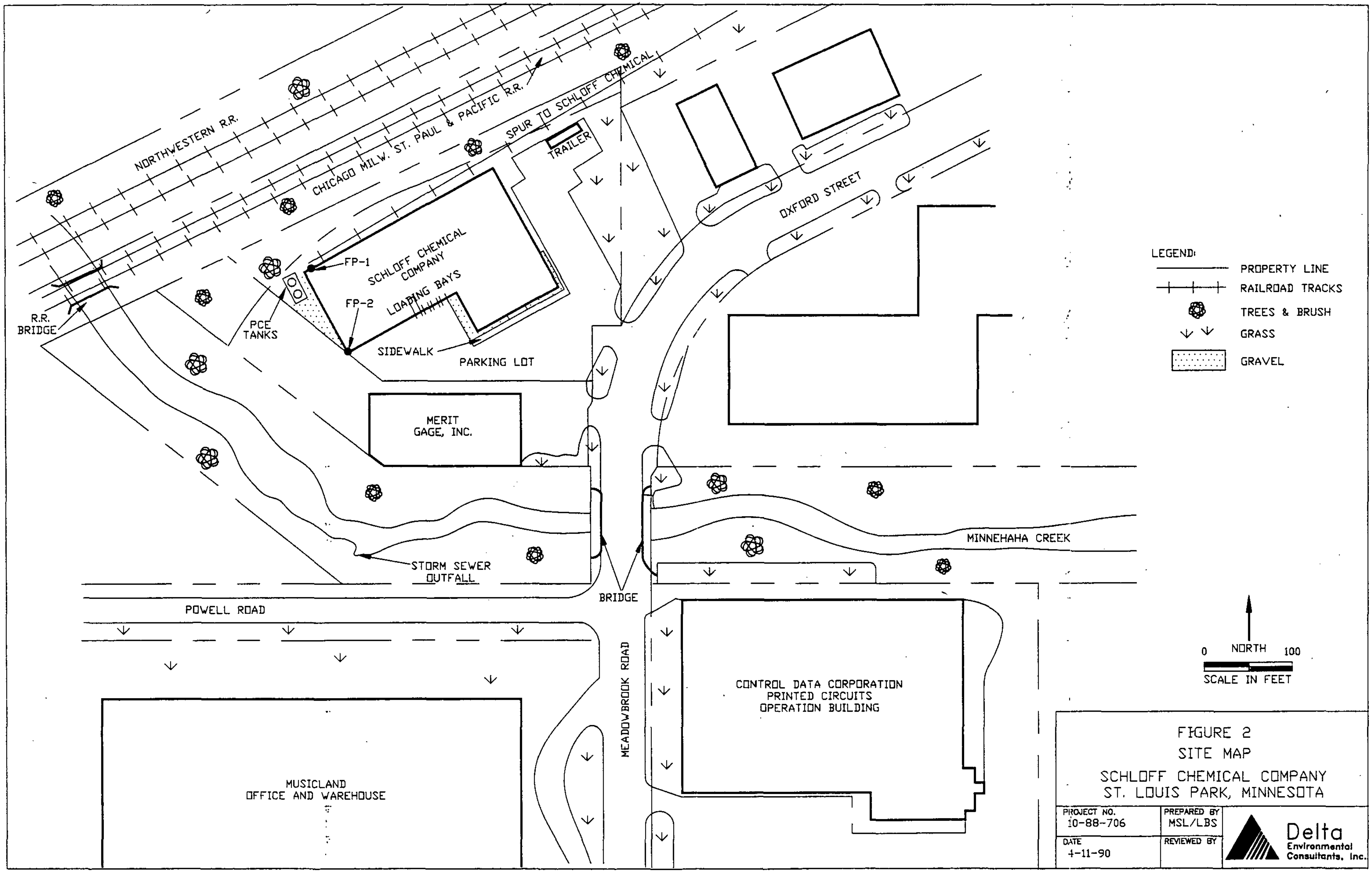
QUADRANGLE LOCATION

44093–H4–TF–024

1967
PHOTOREVISED 1972 AND 1980
DMA 7373 IV NW–SERIES V872

FIGURE 1
SITE LOCATION MAP
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10–88–706	JEM/LBS	Delta Environmental Consultants, Inc.
DATE	REVIEWED BY	
4/14/90		



NORTHWESTERN R.R.
CHICAGO MILW. ST. PAUL & PACIFIC R.R.
SPUR TO SCHLOFF CHEMICAL
TRAILER
SCHLOFF CHEMICAL COMPANY
LOADING BAYS
FP-1
FP-2
PCE TANKS
R.R. BRIDGE
SIDEWALK
PARKING LOT
OXFORD STREET
MERIT GAGE, INC.
STORM SEWER OUTFALL
MINNEHAHA CREEK
BRIDGE
POWELL ROAD
MEADOWBROOK ROAD
CONTROL DATA CORPORATION PRINTED CIRCUITS OPERATION BUILDING
MUSICLAND OFFICE AND WAREHOUSE
LEGEND:
PROPERTY LINE
RAILROAD TRACKS
TREES & BRUSH
GRASS
GRAVEL
NORTH
0
100
SCALE IN FEET
FIGURE 2
SITE MAP
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA
PROJECT NO.
10-88-706
PREPARED BY
MSL/LBS
DATE
4-11-90
REVIEWED BY
Delta Environmental Consultants, Inc.

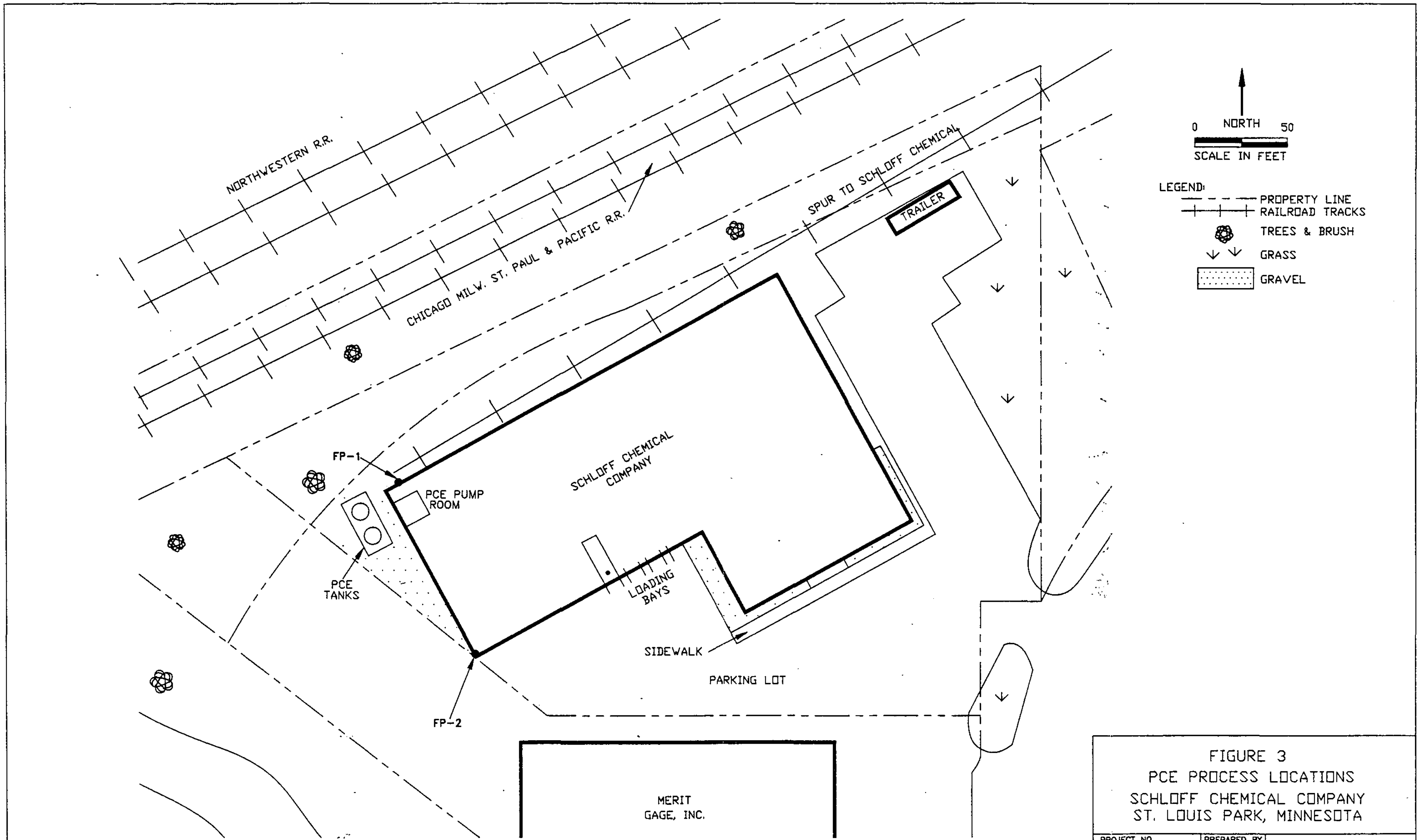


FIGURE 3
PCE PROCESS LOCATIONS
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY
10-88-706	MSL/LBS
DATE	REVIEWED BY
4-11-90	

Delta Environmental Consultants, Inc.

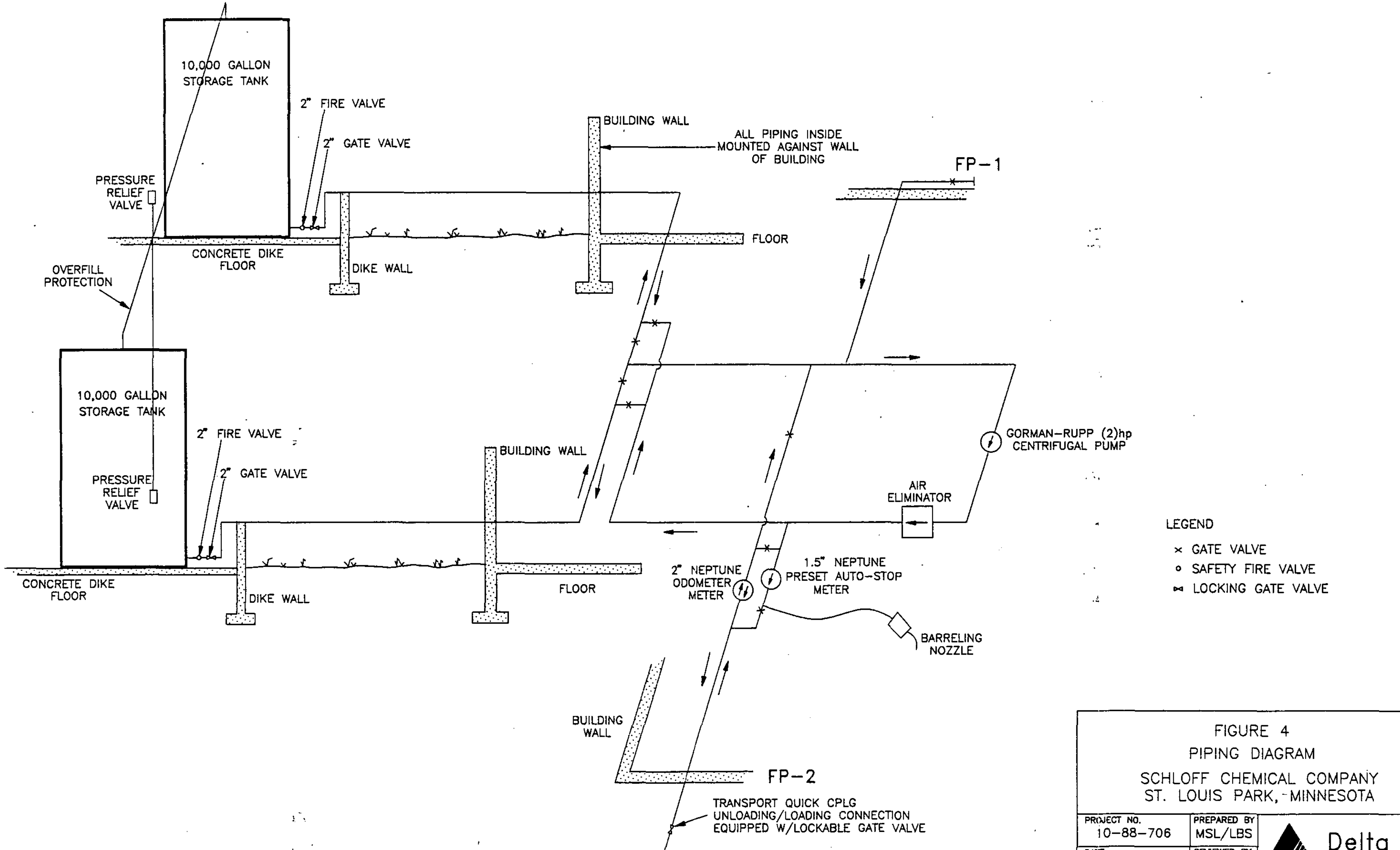


FIGURE 4
PIPING DIAGRAM
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY
10-88-706	MSL/LBS
DATE 4/13/90	REVIEWED BY

Delta Environmental Consultants, Inc.

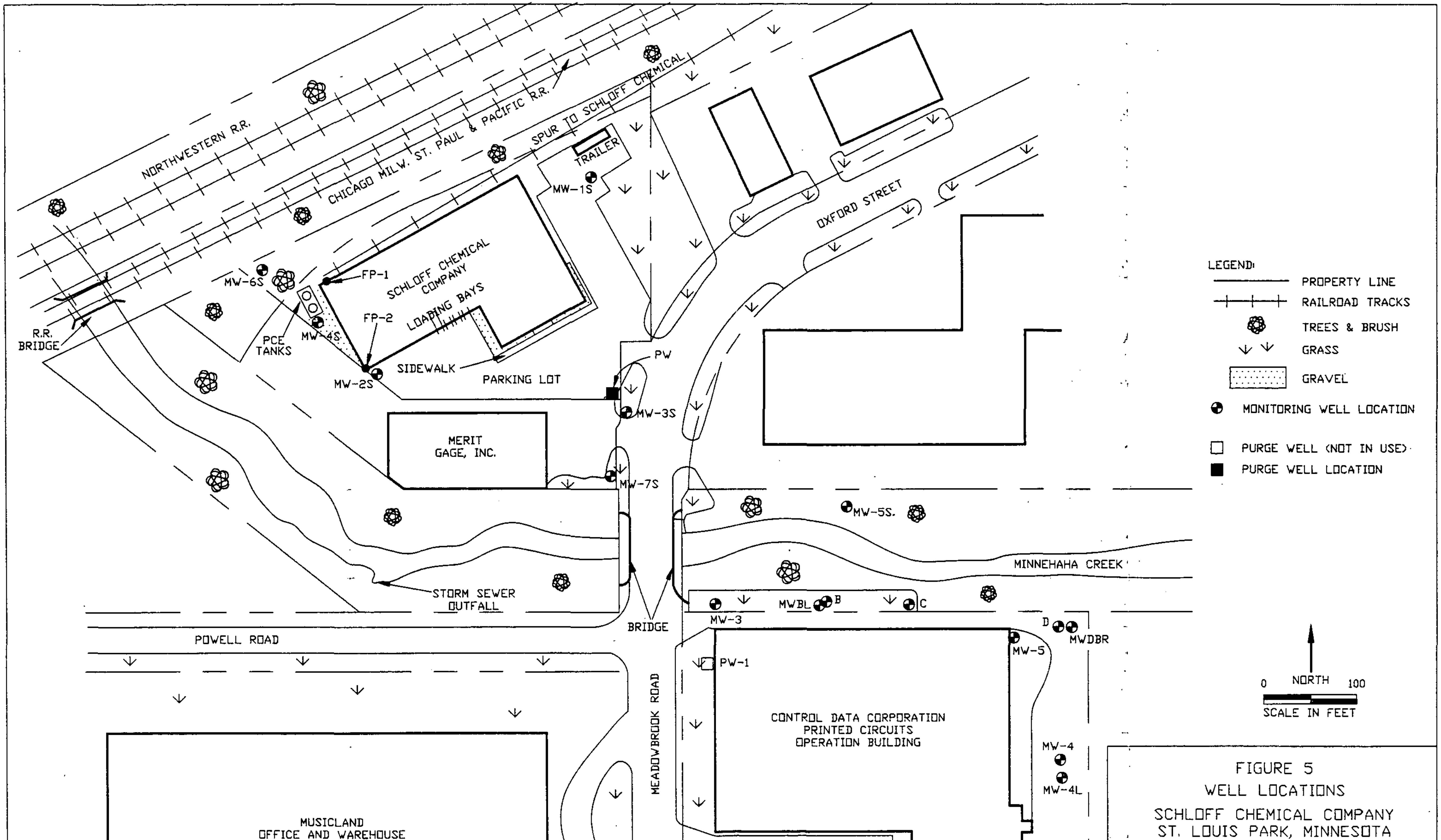


FIGURE 5
WELL LOCATIONS
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	MSL/LBS	Delta Environmental Consultants, Inc.
DATE 4-11-90	REVIEWED BY	

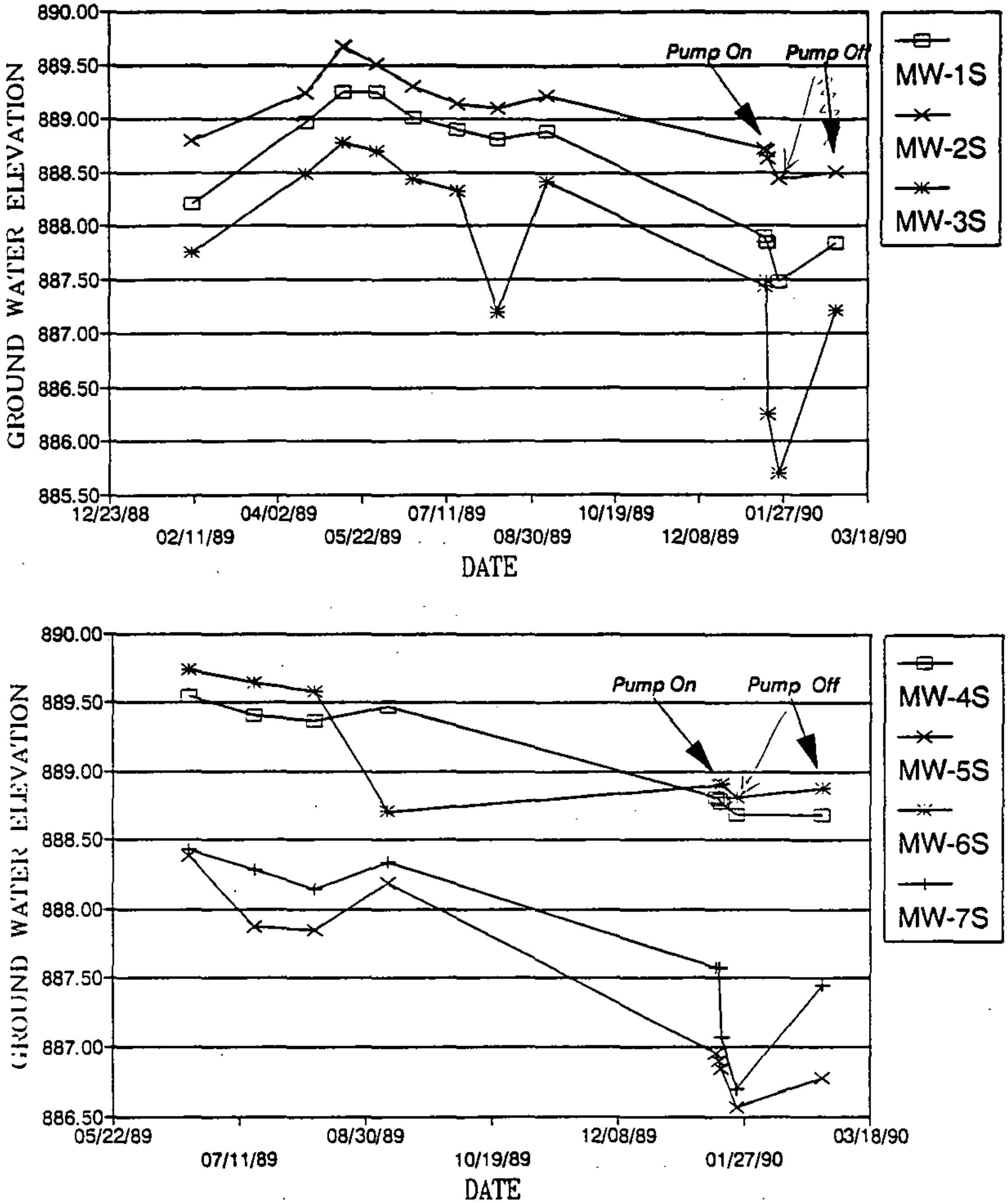


FIGURE 6
HYDROGRAPHS
SCHLOFF CHEMICAL CO.
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	MSL	Delta Environmental Consultants, Inc.
DATE 4/11/90	REVIEWED BY	

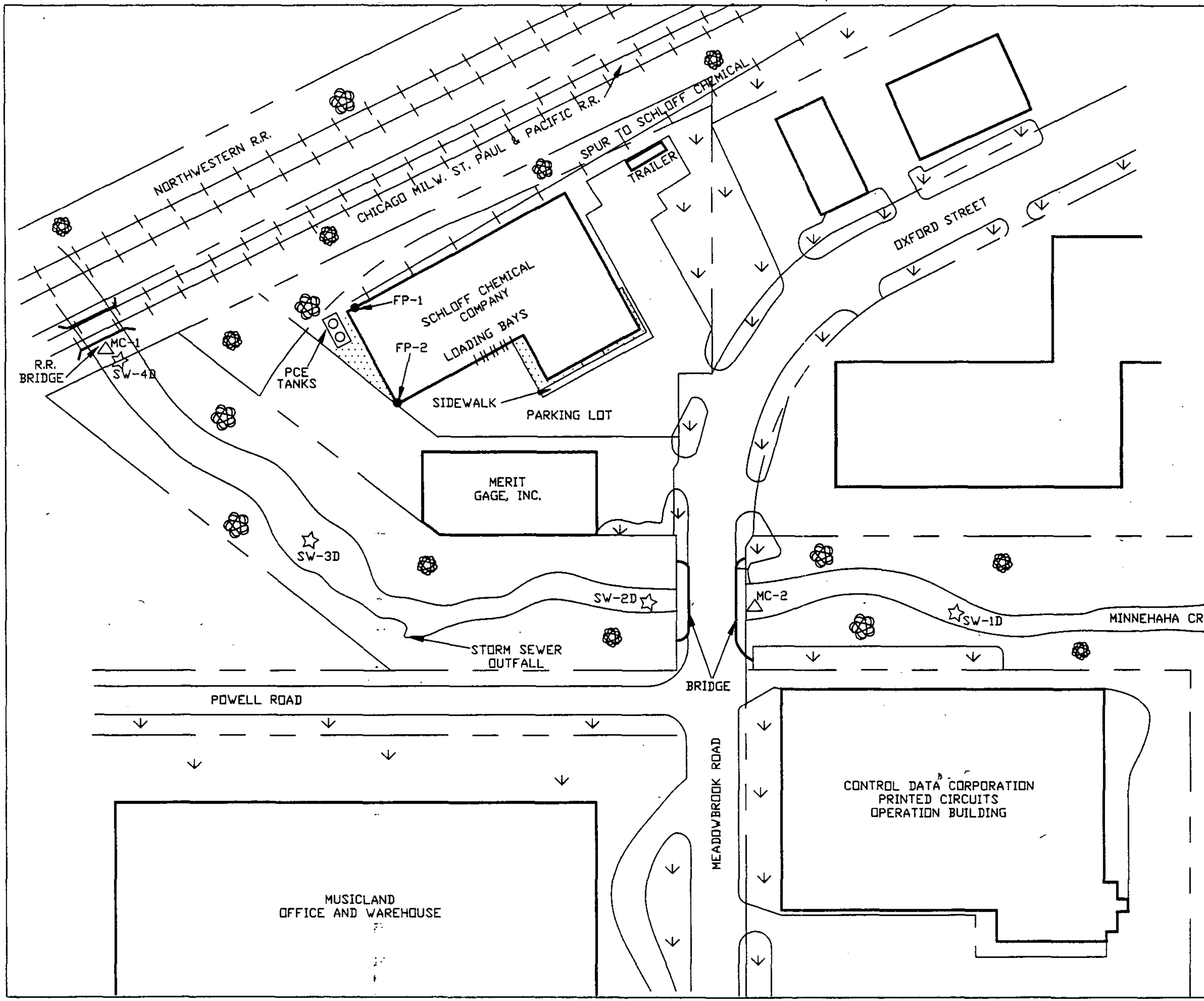


FIGURE 7
MINNEHAHA CREEK SAMPLING POINTS
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY
10-88-706	MSL/LBS
DATE	REVIEWED BY
4-11-90	

Delta Environmental Consultants, Inc.

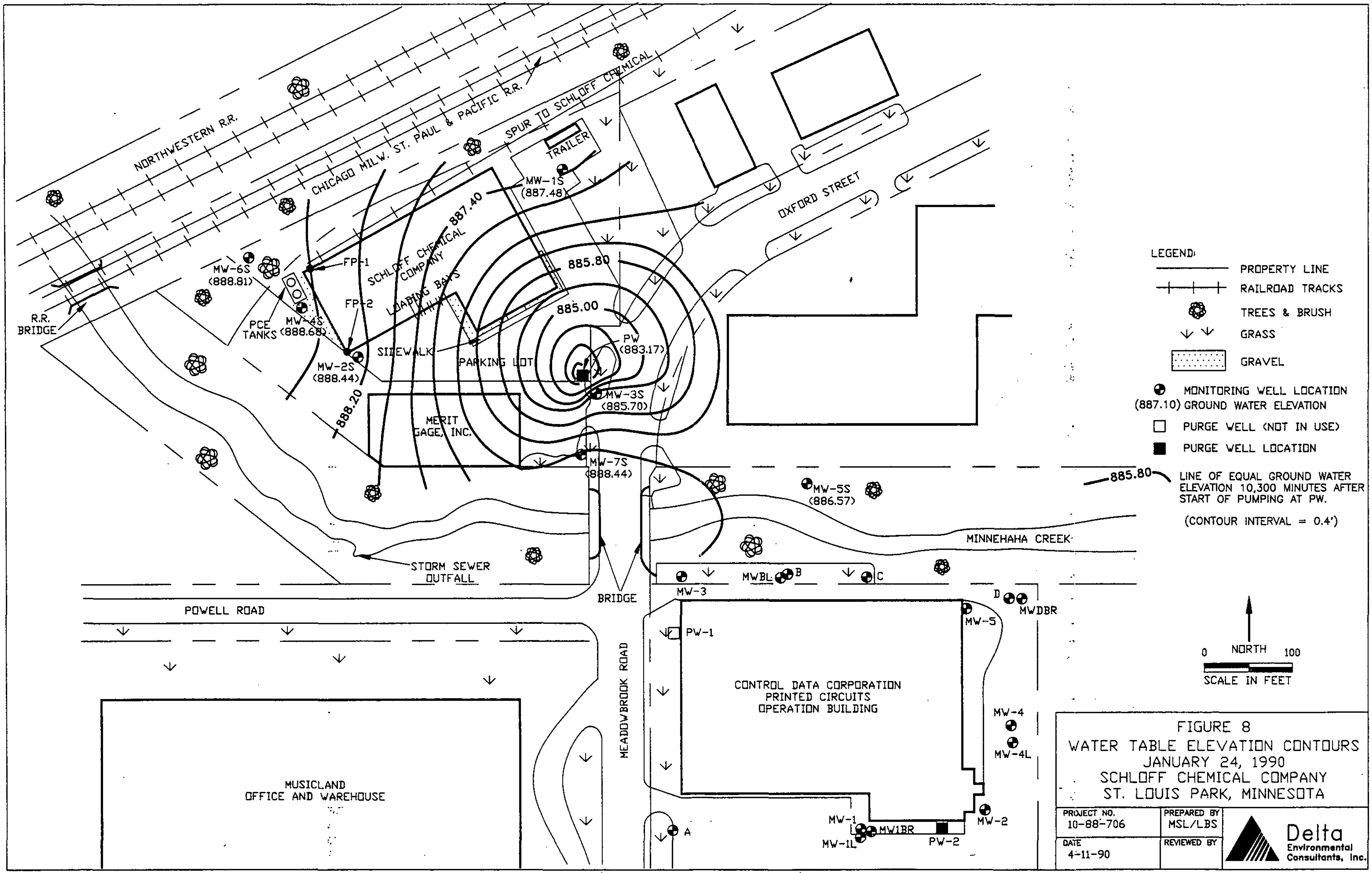


FIGURE 8
WATER TABLE ELEVATION CONTOURS
JANUARY 24, 1990
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	MSL/LBS	Delta Environmental Consultants, Inc.
DATE 4-11-90	REVIEWED BY	

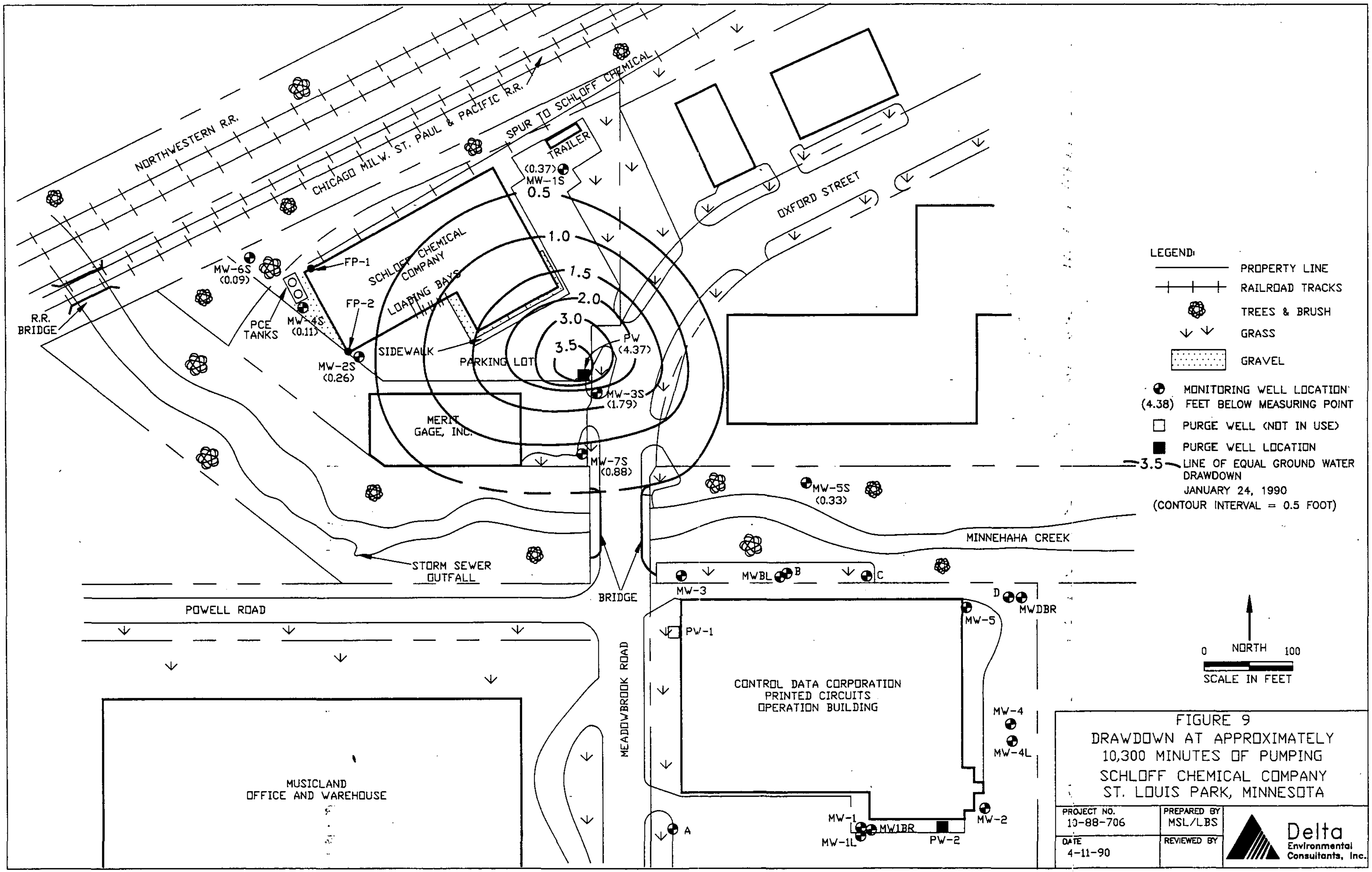


FIGURE 9
DRAWDOWN AT APPROXIMATELY 10,300 MINUTES OF PUMPING
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO. 10-88-706	PREPARED BY MSL/LBS
DATE 4-11-90	REVIEWED BY

Delta Environmental Consultants, Inc.

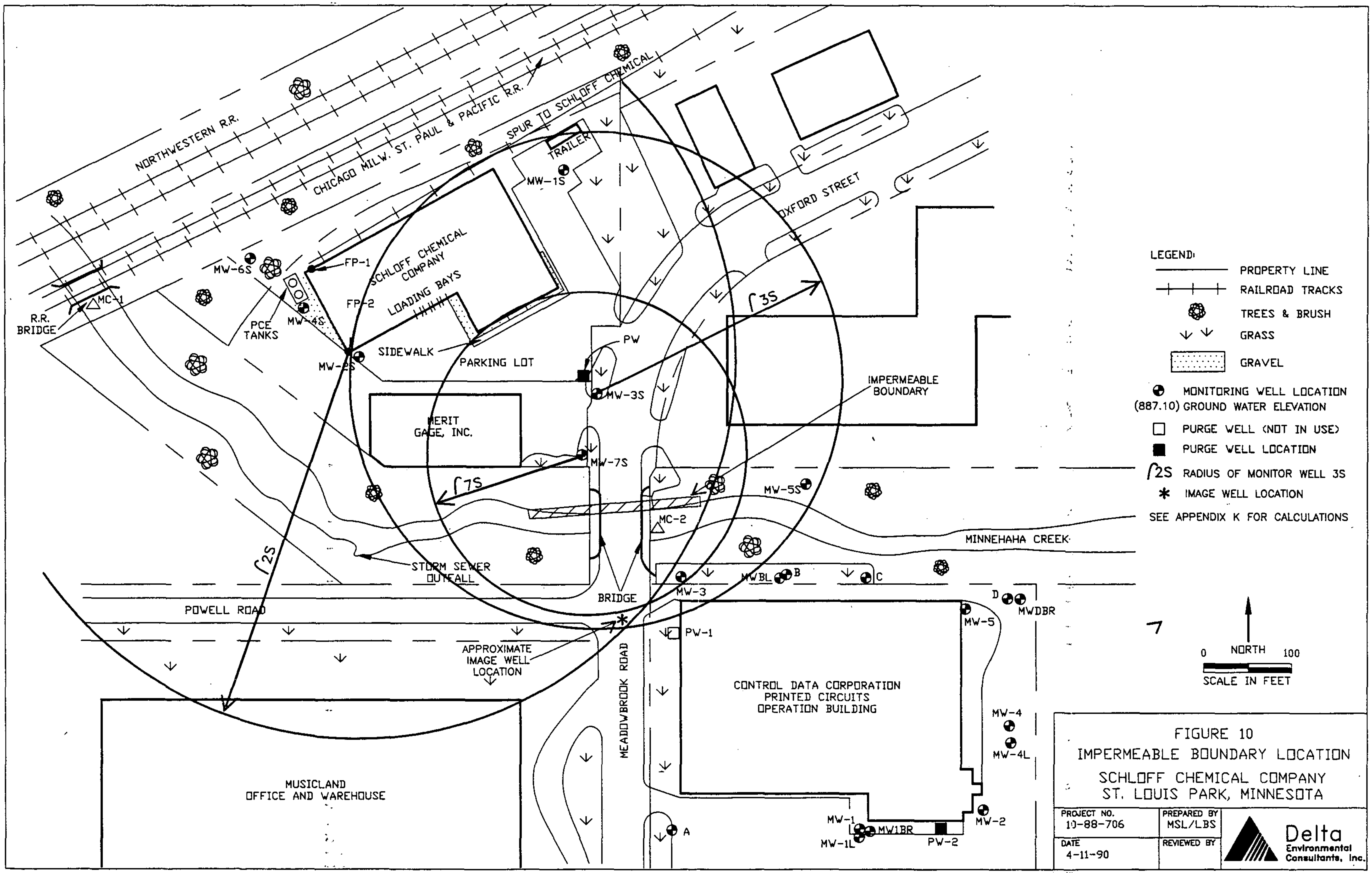


FIGURE 10
IMPERMEABLE BOUNDARY LOCATION
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	MSL/LBS	Delta Environmental Consultants, Inc.
DATE 4-11-90	REVIEWED BY	

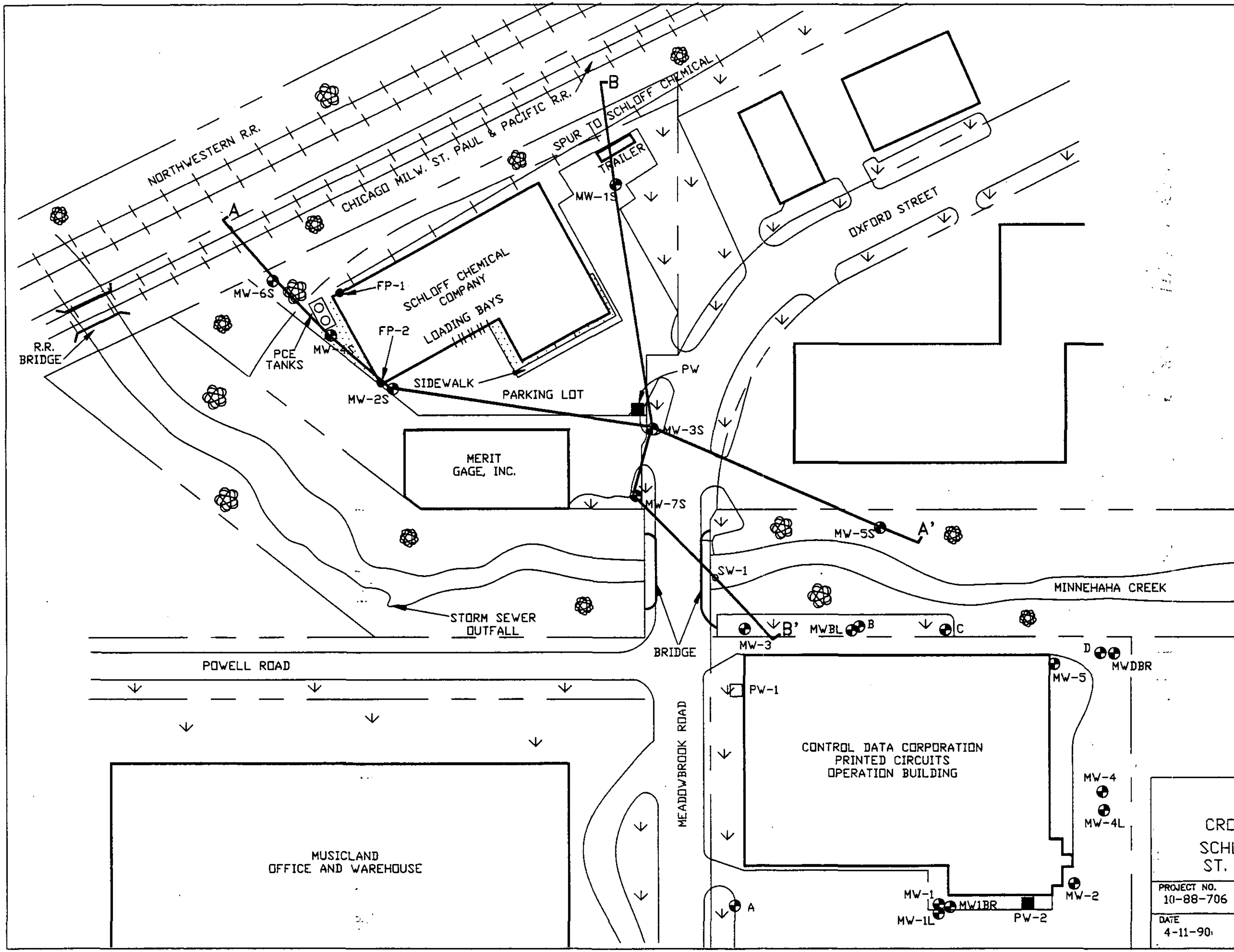


FIGURE 11
CROSS SECTION LOCATIONS
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY
10-88-706	MSL/LBS
DATE	REVIEWED BY
4-11-90	

Delta Environmental Consultants, Inc.

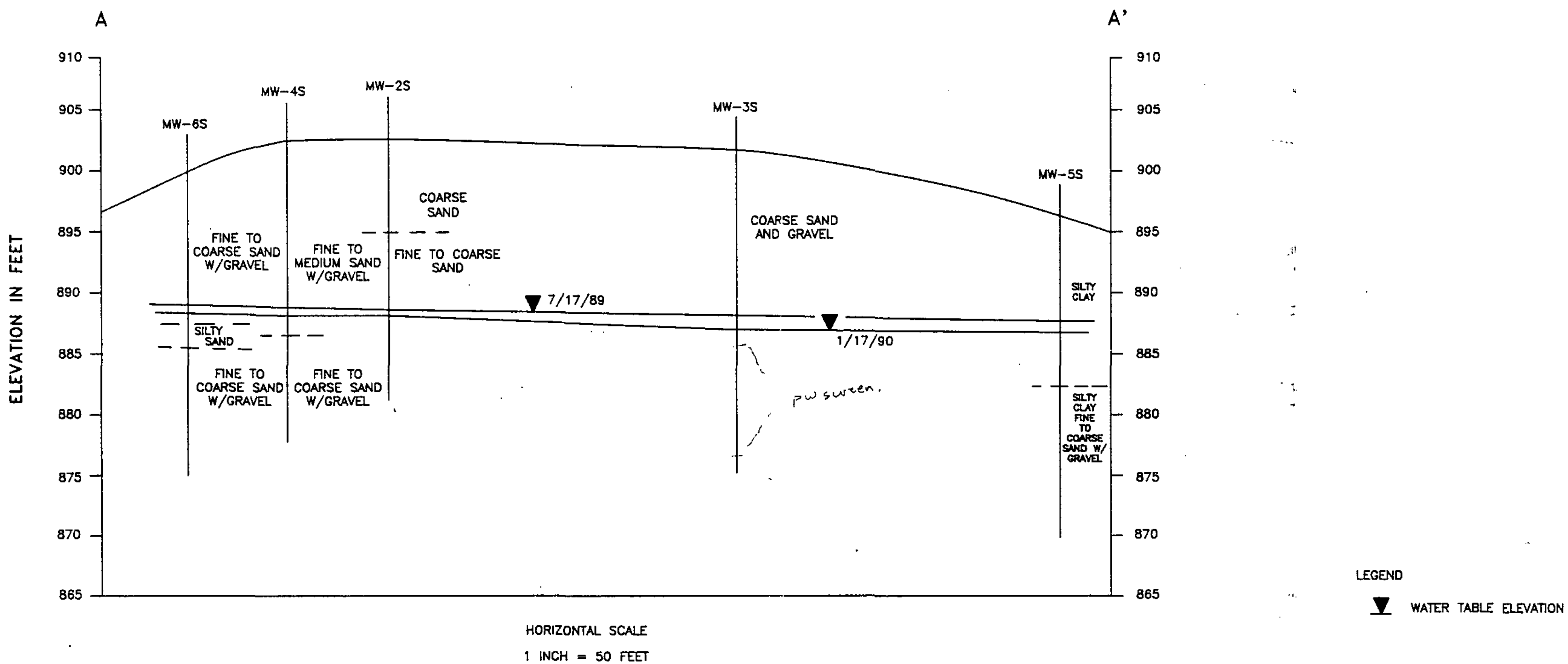


FIGURE 12
CROSS SECTION A – A'
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	MSL/LBS	Delta Environmental Consultants, Inc.
DATE 4/13/90	REVIEWED BY	

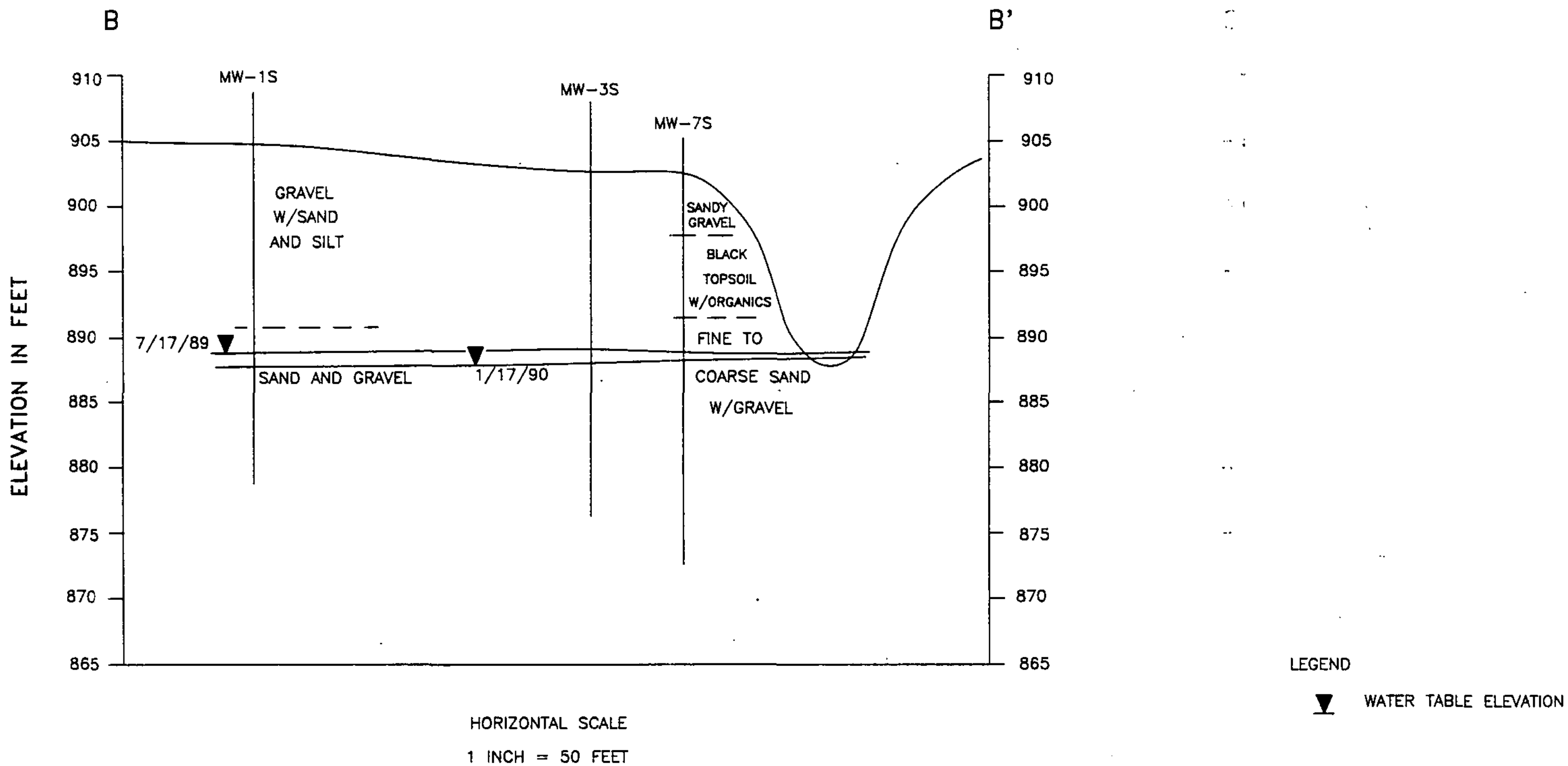


FIGURE 13
CROSS SECTION B – B'
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	MSL/LBS	Delta Environmental Consultants, Inc.
DATE 4/13/90	REVIEWED BY	

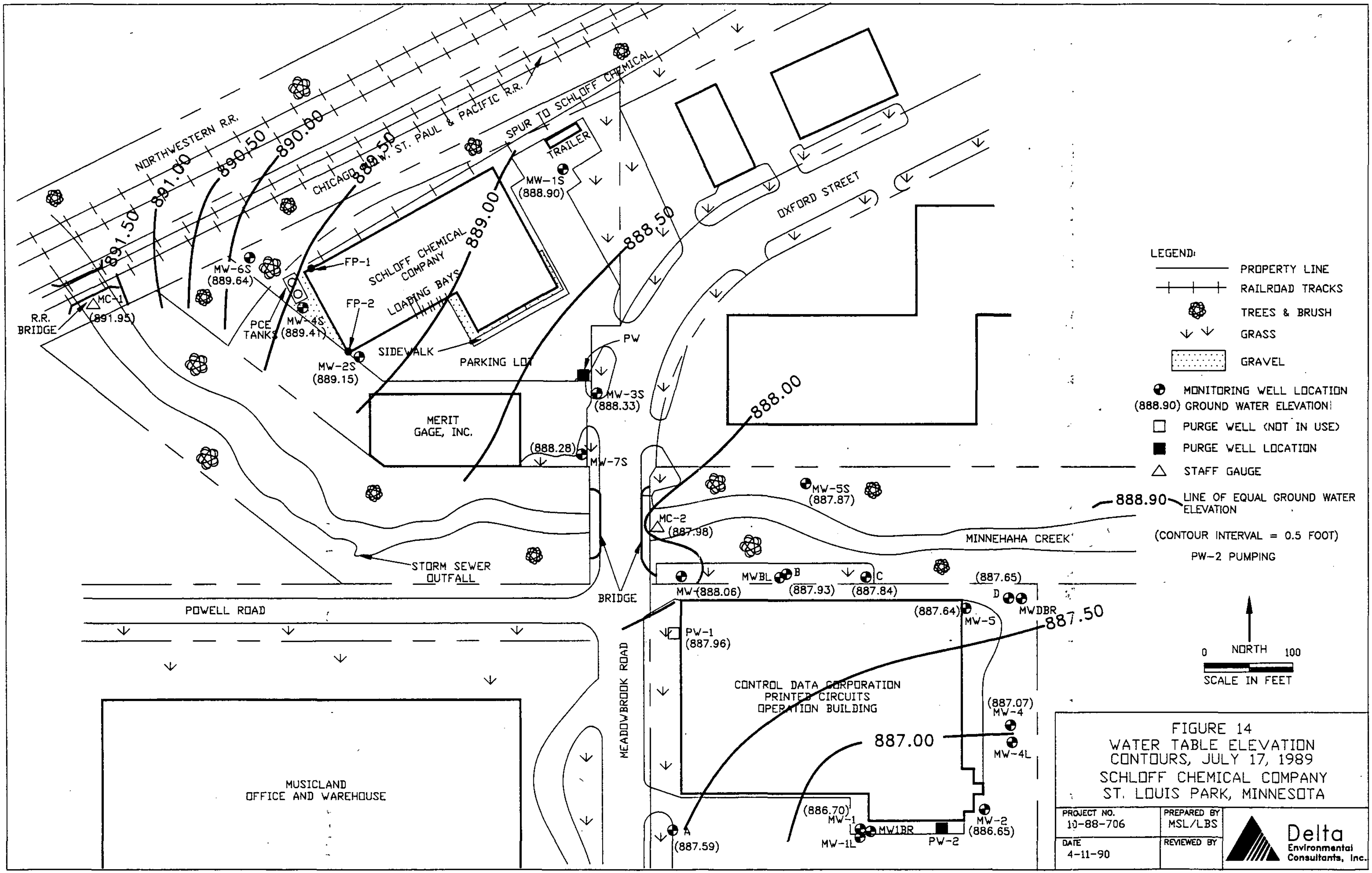


FIGURE 14
WATER TABLE ELEVATION CONTOURS, JULY 17, 1989
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO. 10-88-706	PREPARED BY MSL/LBS
DATE 4-11-90	REVIEWED BY

Delta Environmental Consultants, Inc.

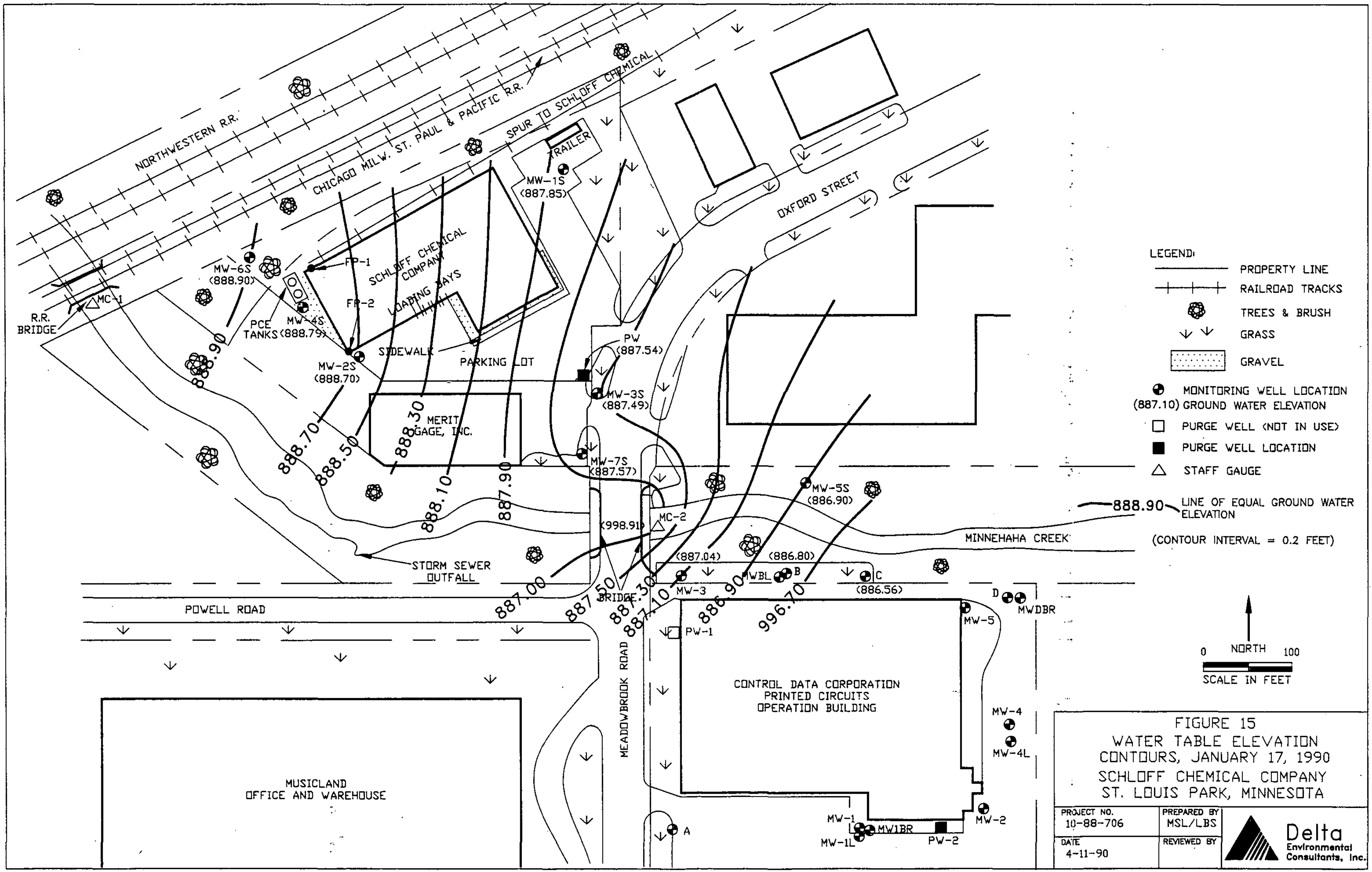
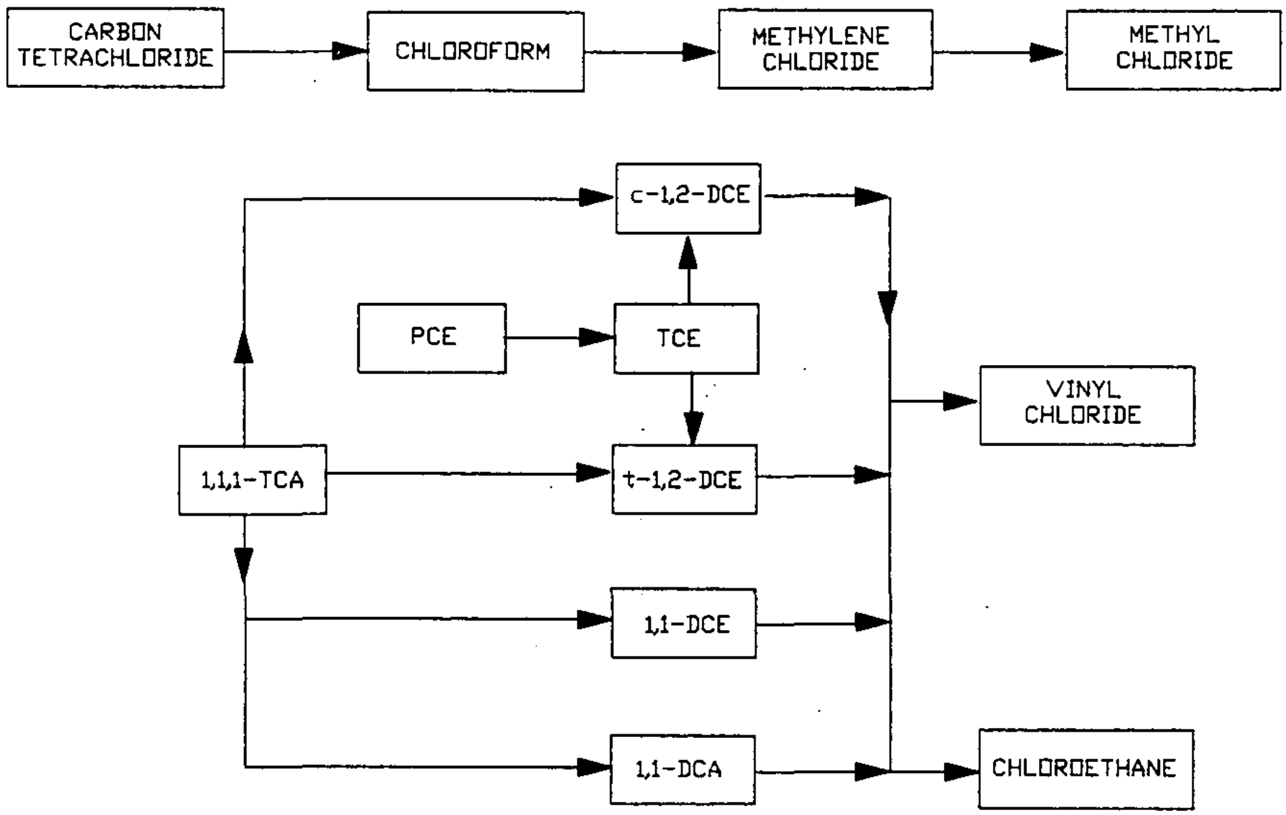


FIGURE 15
WATER TABLE ELEVATION CONTOURS, JANUARY 17, 1990
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA



(SMITH & DRAGUN, 1984)

FIGURE 16
VOC TRANSFORMATION PATHWAYS
SCHLOFF CHEMICAL
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	JEM/LBS	Delta Environmental Consultants, Inc.
DATE	REVIEWED BY	
4/14/90		

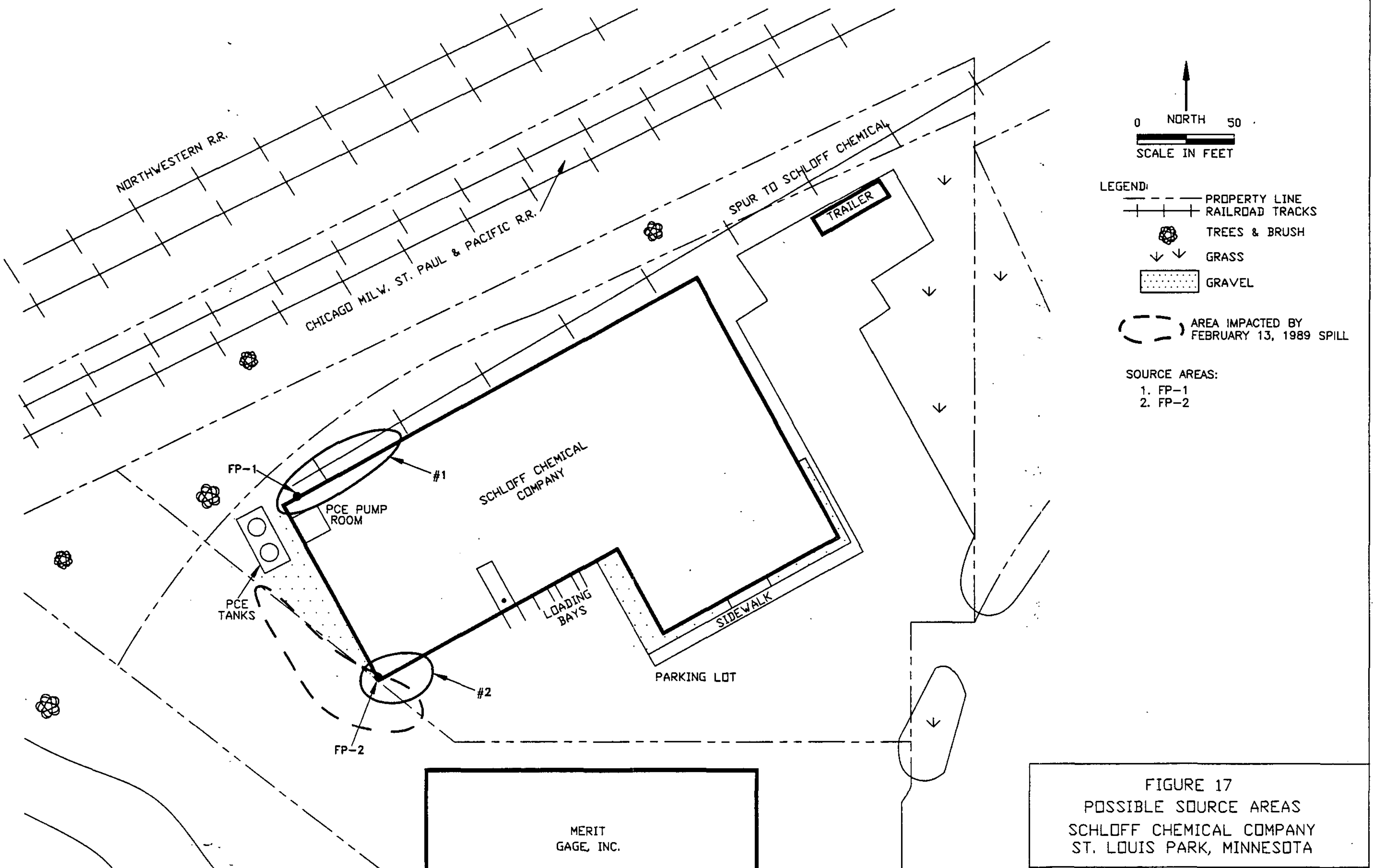


FIGURE 17
POSSIBLE SOURCE AREAS
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	MSL/LBS	Delta Environmental Consultants, Inc.
DATE	REVIEWED BY	
5/15/90		

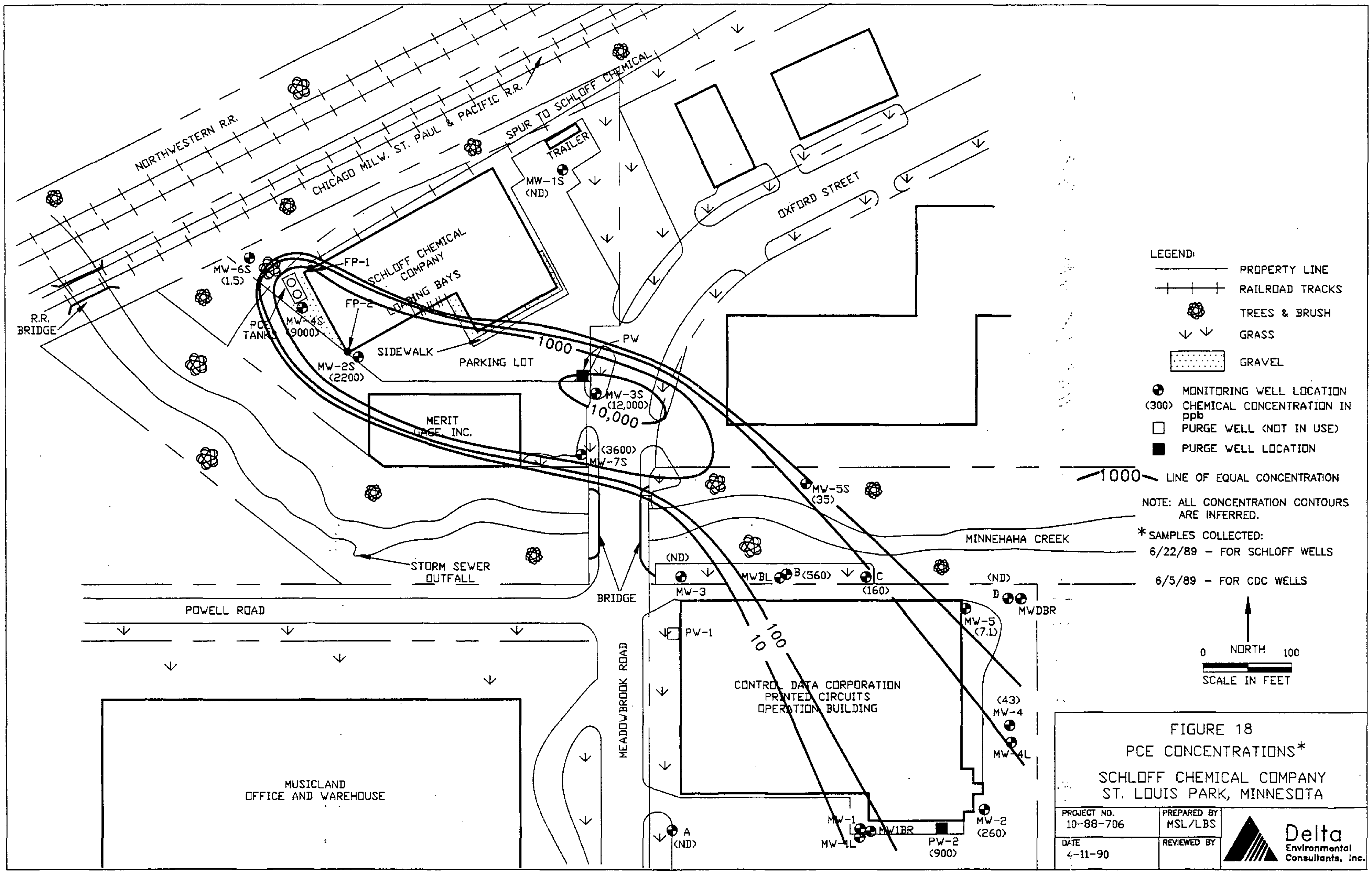


FIGURE 18
PCE CONCENTRATIONS*
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY
10-88-706	MSL/LBS
DATE 4-11-90	REVIEWED BY

Delta Environmental Consultants, Inc.

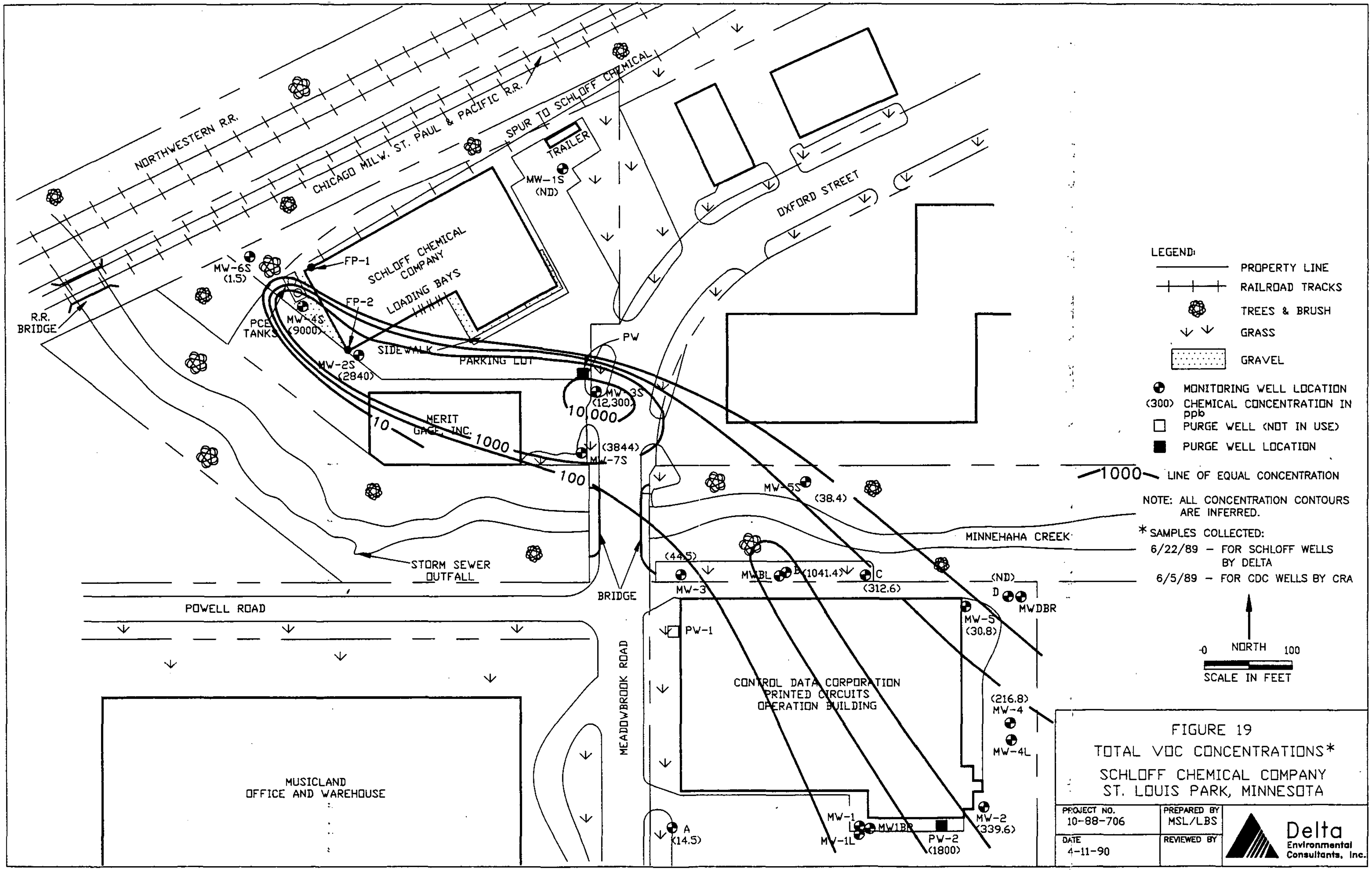


FIGURE 19
TOTAL VOC CONCENTRATIONS*
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

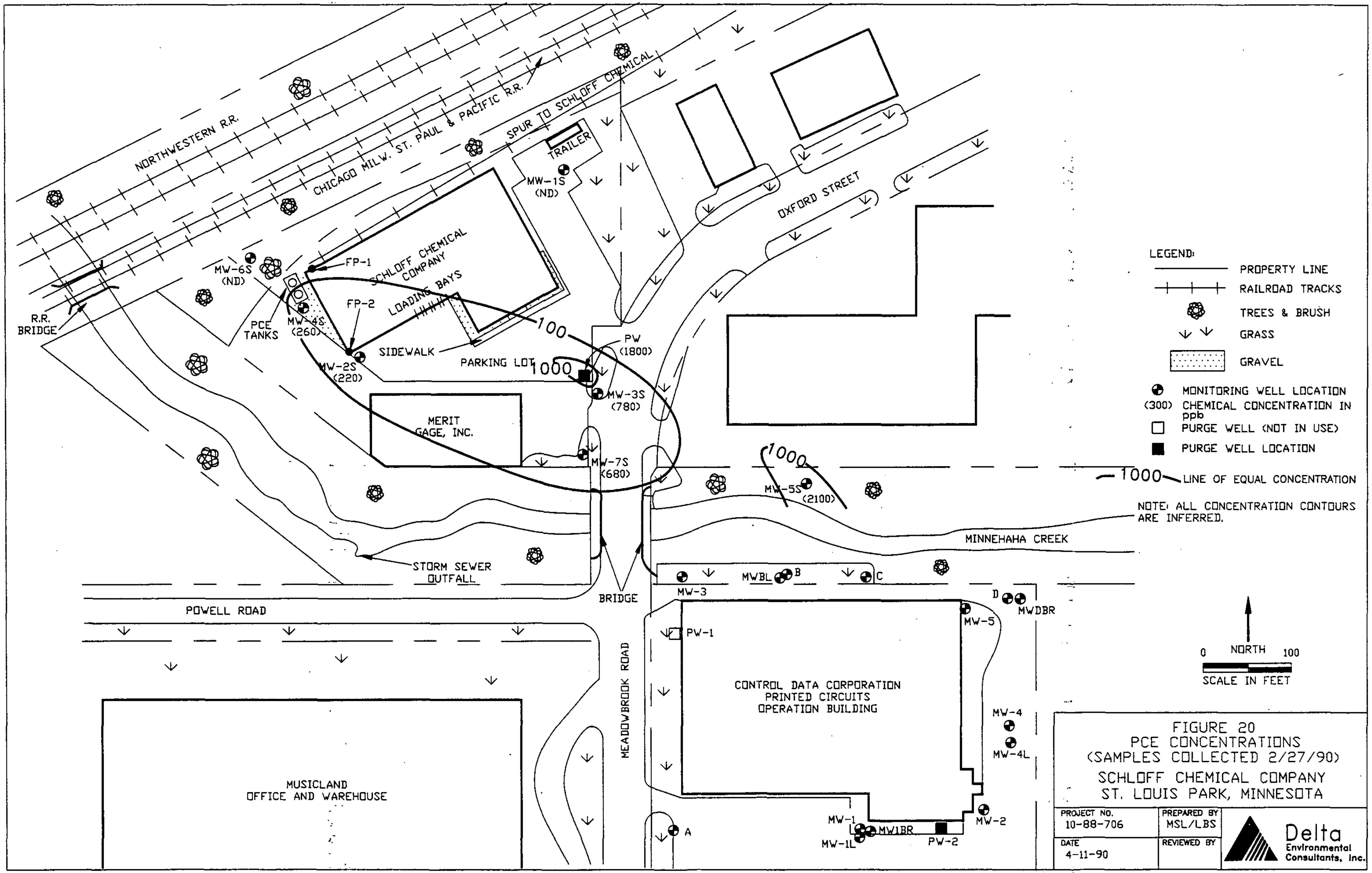


FIGURE 20
PCE CONCENTRATIONS
(SAMPLES COLLECTED 2/27/90)
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO. 10-88-706	PREPARED BY MSL/LBS	Delta Environmental Consultants, Inc.
DATE 4-11-90	REVIEWED BY	

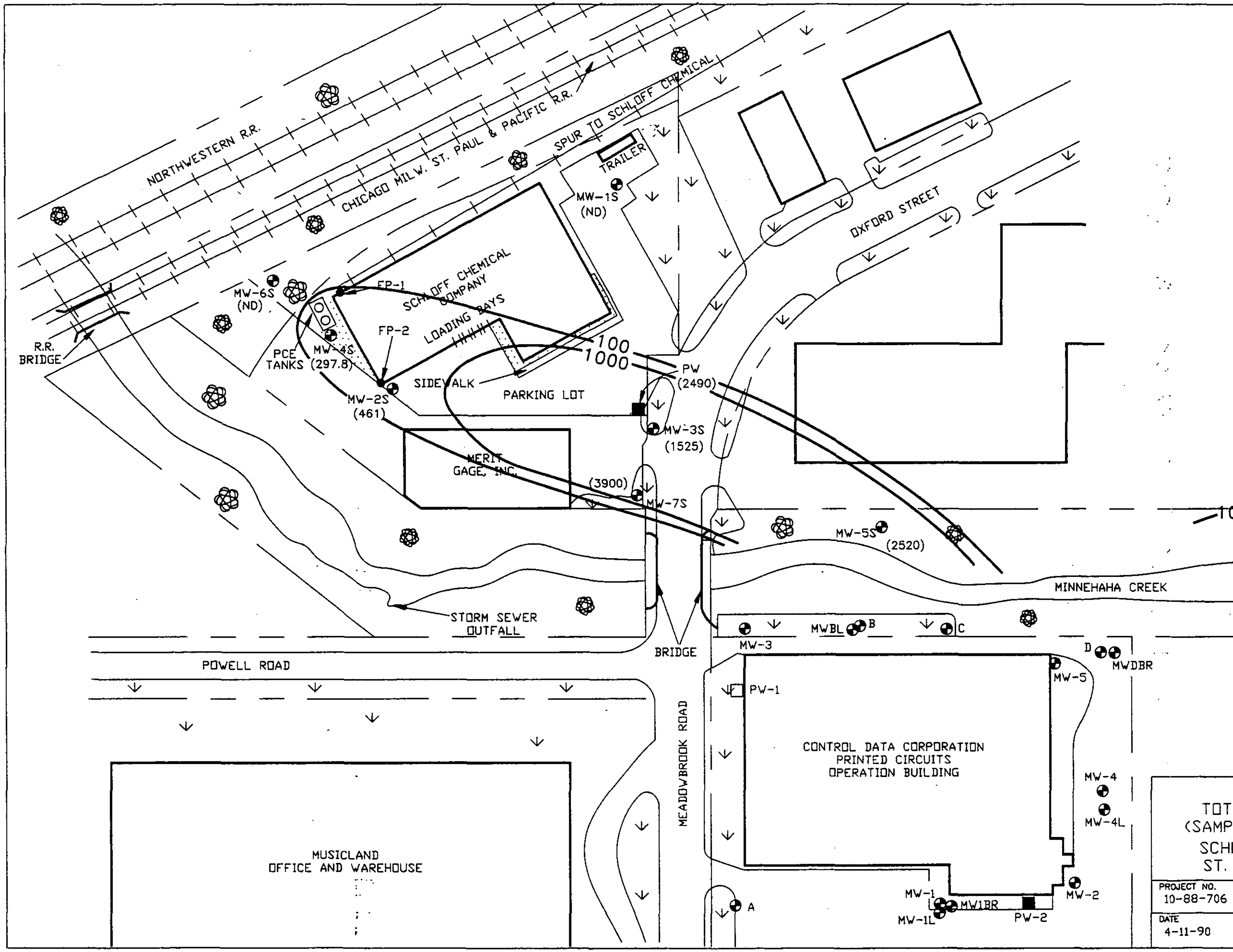


FIGURE 21
TOTAL VOC CONCENTRATION
(SAMPLES COLLECTED 2/27/90)
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO. 10-88-706	PREPARED BY MSL/LBS
DATE 4-11-90	REVIEWED BY

Delta Environmental Consultants, Inc.

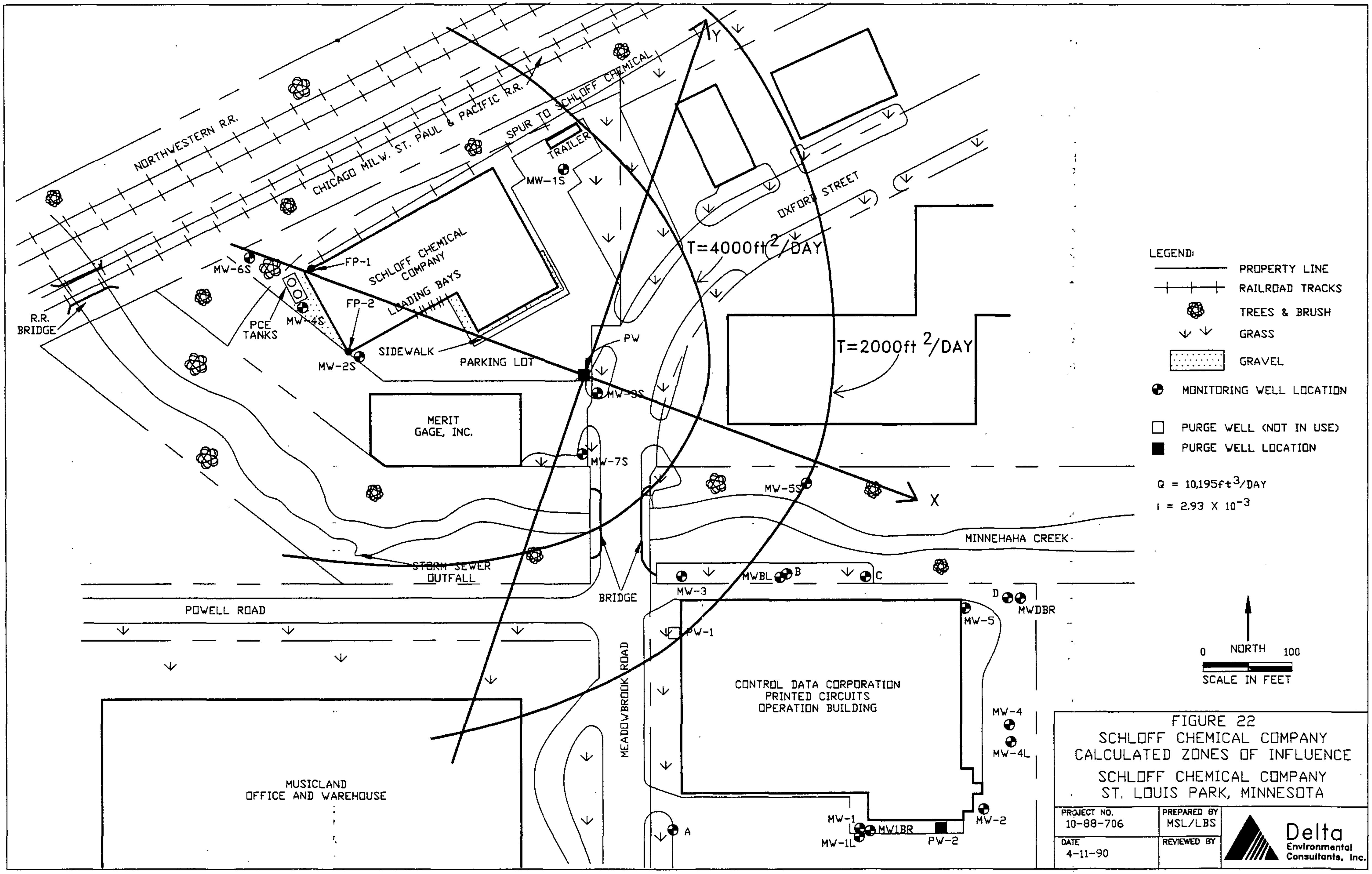


FIGURE 22
SCHLOFF CHEMICAL COMPANY
CALCULATED ZONES OF INFLUENCE

SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

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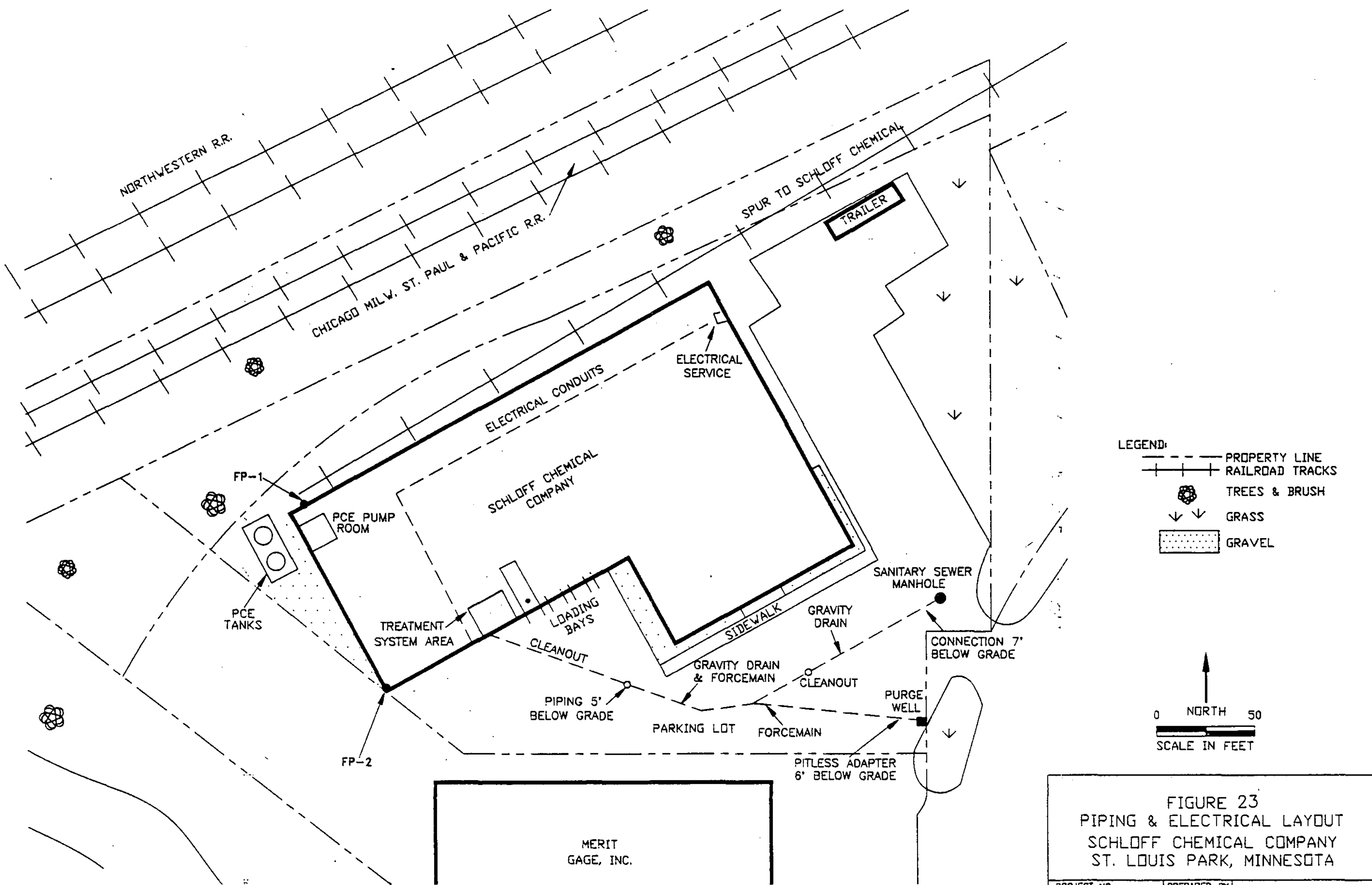

FIGURE 23
PIPING & ELECTRICAL LAYOUT
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

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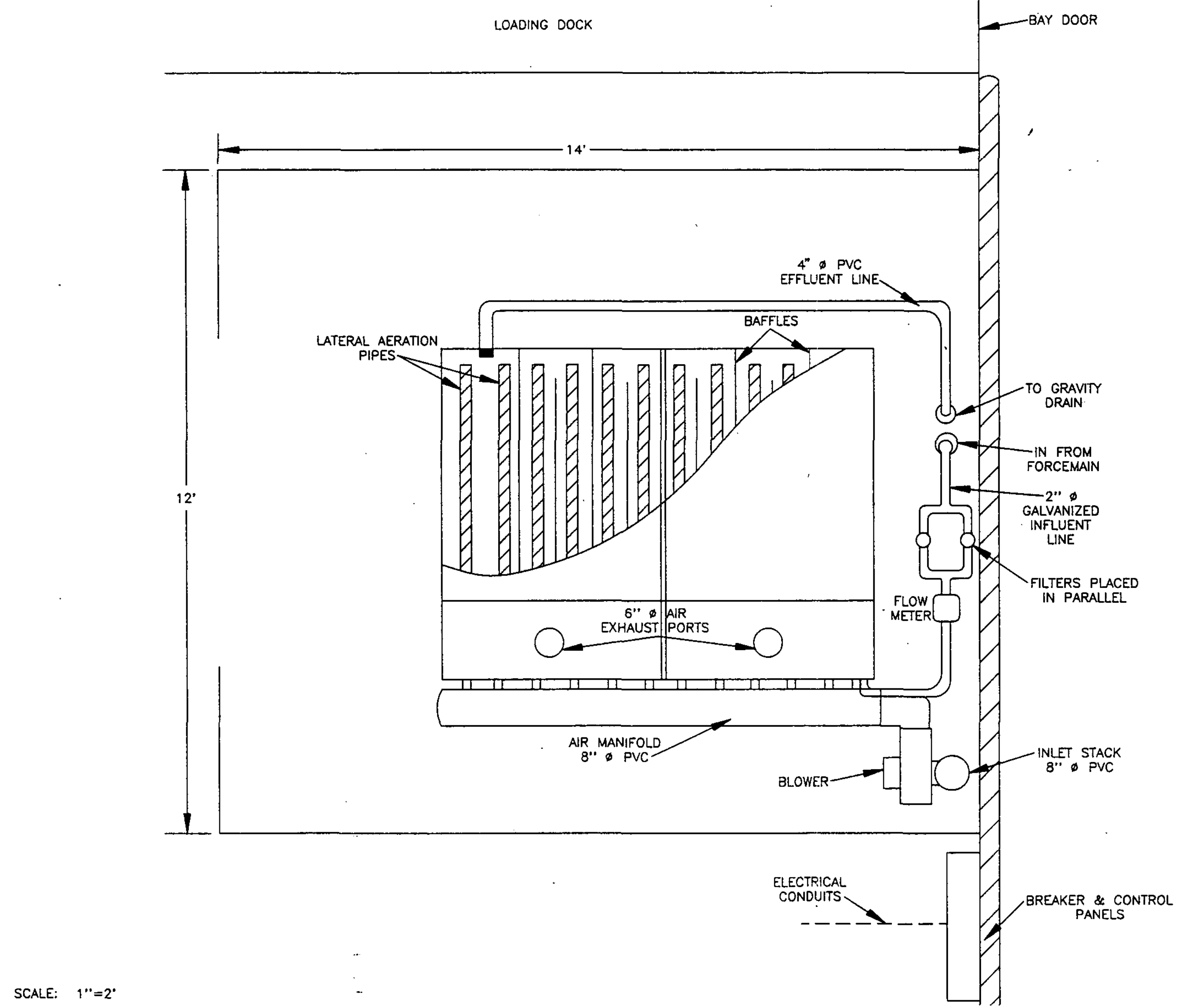

FIGURE 24
SYSTEM & SHELTER PLAN VIEW
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

PROJECT NO.	PREPARED BY	
10-88-706	JEM/LS	Delta Environmental Consultants, Inc.
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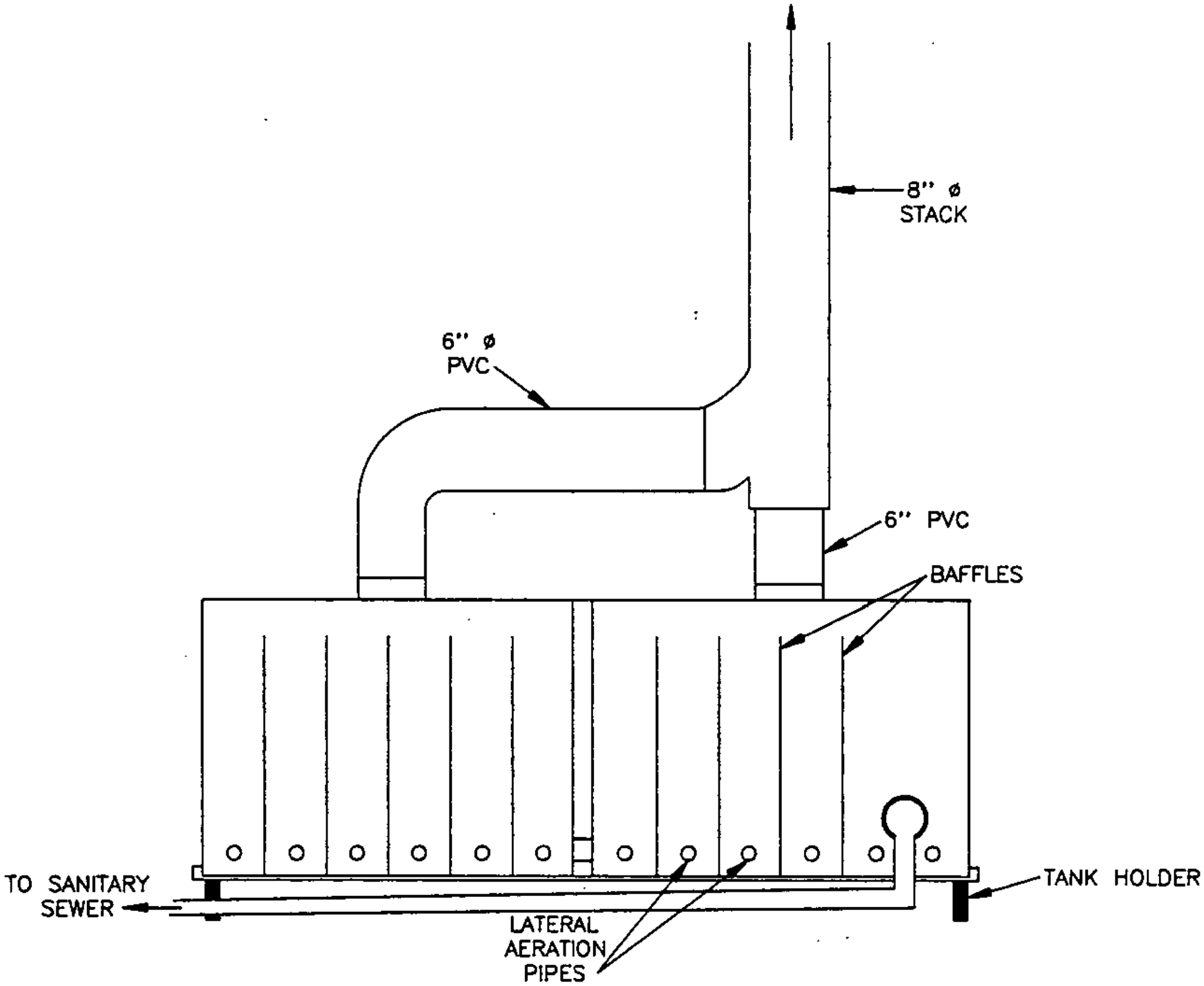

FIGURE 25
TREATMENT SYSTEM END VIEW
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

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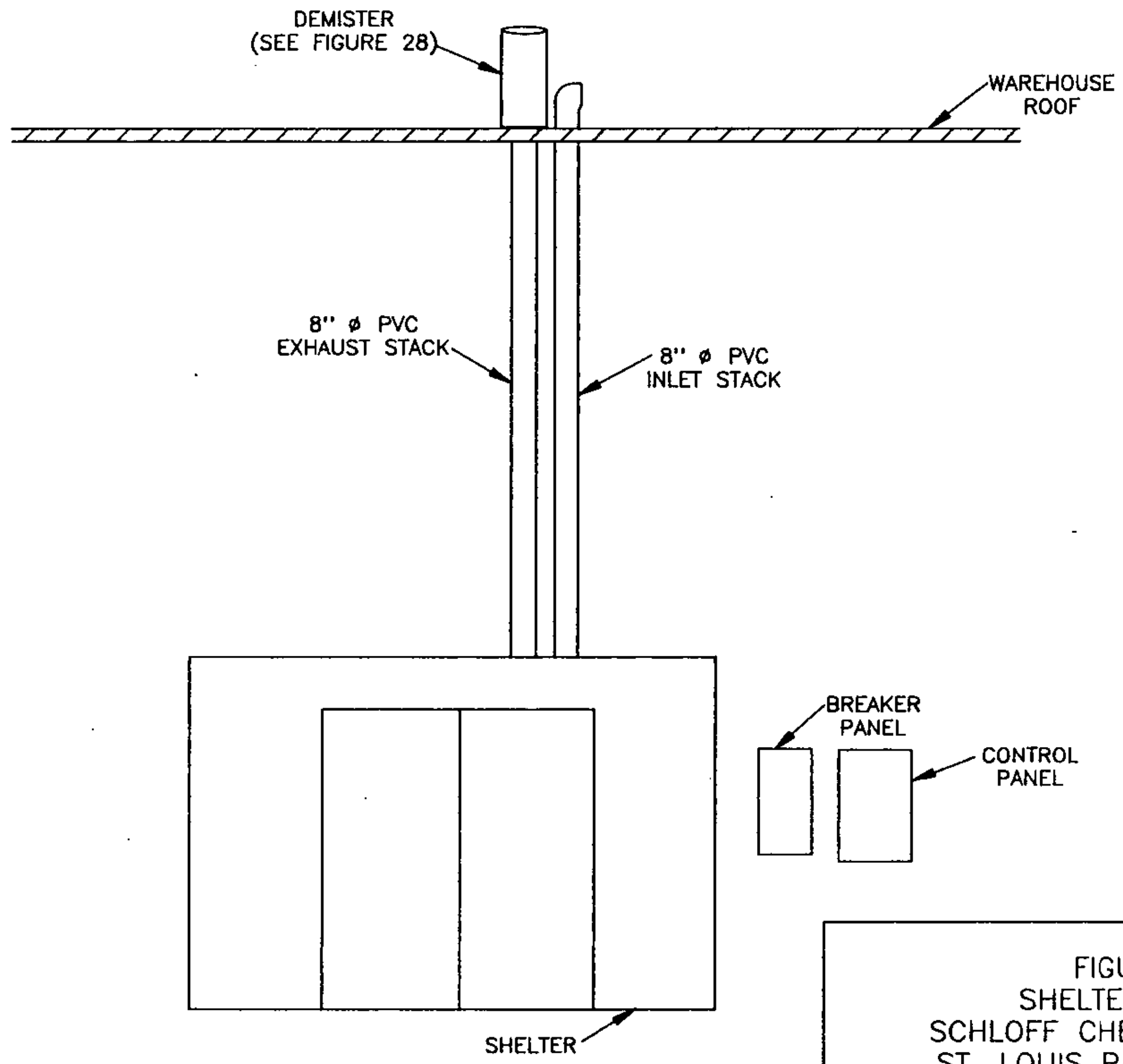

FIGURE 26
SHELTER–PROFILE
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

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Consultants, Inc.

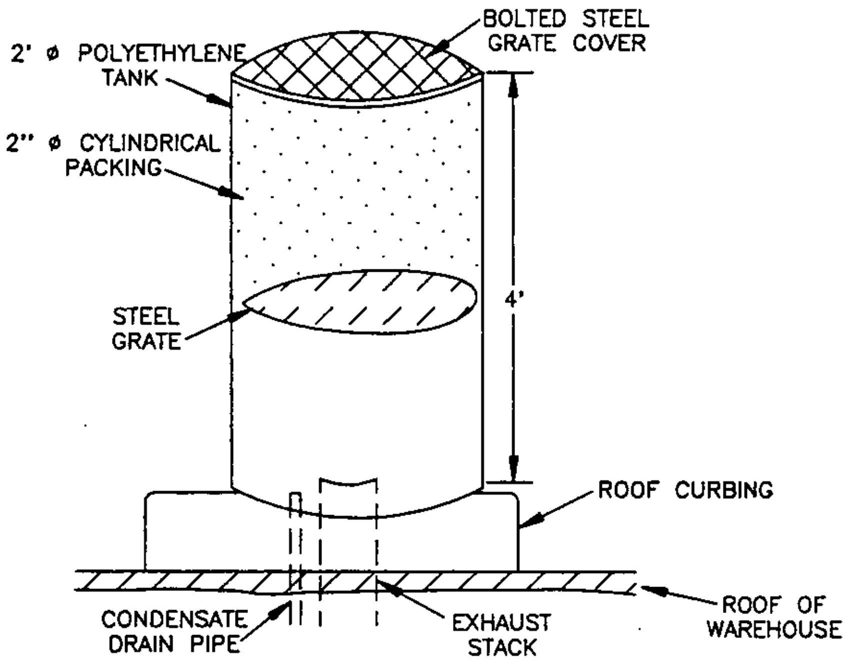

FIGURE 27
DEMISTER–PROFILE
SCHLOFF CHEMICAL COMPANY
ST. LOUIS PARK, MINNESOTA

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5/15/90		